DETERMINANTS OF ADOPTION OF THE COCOA BLACK POD DISEASE CONTROL TECHNOLOGY IN THE ASHANTI REGION, GHANA

BY

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DECLARATION

I, Boateng, Peter Okyere, author of this thesis do hereby declare that, except for references to the works of other writers, which have been duly cited, the work presented in this thesis: "Determinants of Adoption of the Cocoa Black Pod Disease Control Technology in the Ashanti Region, Ghana" was done entirely by me in the Department of Agricultural Economics and Agribusiness, University of Ghana, Legon.

This work has never been submitted either in whole or in part for any other degree of this University or elsewhere.

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DEDICATION

Dedicated to my dear wife, Lydia Okyere Boateng (Mrs) and my five children, Emelia, Kwabena Boateng, Akwasi Osei-Akoto, Kofi Aboagye and Akwasi Agyemang (Junior).

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ABSTRACT

Cocoa production, one of the most important economic activities in the Ashanti Region of Ghana, has for sometime now been bedevilled with several problems. The most important of these is the black pod disease caused by the *Phytophthora megakarya* strain of fungus, which is destroying pods in large quantities and thus causing substantial financial loss to cocoa farmers. Research has made available a tried and tested control technology whose adoption in the Ashanti Region is very low. This study was, therefore, conducted to specifically evaluate the cocoa farmers' awareness and perceptions about the black pod disease and the control technology, cost implications of using the technology and the current extent of use. The study used the logit model to examine the factors which influence adoption of the technology.

Cocoa farmers showed high degree of awareness about the disease and the recommended technology but perceived the application of the technology to be tedious, costly, and time consuming. The recommended technology was found to contribute 36% of the total cost of cocoa production, which confirmed the perception of the high cost of the technology. The estimated acceptability index was 16%, indicating low extent of adoption of the technology, while extent of use among adopters was 75%. It was found that education, available household labour, extension contacts, and access to credit influence adoption positively; while age, gender, farm size, off-farm income, distance to source of inputs, and input prices negatively affect adoption of the technology. To improve the adoption of the recommended technology, the study recommends that research improves the attributes of the technology and the research-extension-farmer linkage strengthened. More younger and educated farmers should be encouraged to go into cocoa production, and input distribution network should be improved. Re-introduction of the inputs subsidy needs to be revisited; and finally, farmers should be reorganised into cooperatives and associations to improve their ability to access credit.

Addressing these policy issues would encourage the farmers to take over the spraying of their farms in place of the mass spraying exercise, which is fraught with problems relating to inputs handling, wider coverage of farms and higher spraying frequencies as recommended by research.

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

TABLES

FIGURES

LIST OF ACRONYMS

COCOBOD	Ghana Cocoa Board
CRIG	Cocoa Research Institute of Ghana
CIMMYT	International Maize and Wheat Improvement Centre
ICO	International Cocoa Organization
IFPRI	International Food Policy Research Institute
ISSER	Institute of Statistical, Social and Economic Research

CHAPTER ONE

INTRODUCTION

1.1. Background

Improving the performance of the cocoa sub-sector in Ghana is of crucial importance to the country's development for a variety of reasons. Cocoa has been the mainstay of Ghana's economy since it was first introduced into the country in 1876. It occupied an estimated area of about 1.2 million hectares according to the final report of the last cocoa tree stock survey conducted in 1997 (COCOBOD, 1998). The cocoa sub-sector provided an average of 27.5 percent of the total export earnings for the period 1996 to 2001, and 9.2 percent of the total agricultural domestic product for the year 2001 (ISSER, 2002). The sector is also estimated to employ between 300,000 and 400,000 of the agricultural labour force, and these farmers grow other crops in addition to cocoa (COCOBOD, 1998). It also serves as a major source of revenue for the provision of the country's socio-economic infrastructure such as schools, hospitals and roads, among others (COCOBOD, 1995).

Given the role of the cocoa sector in the economy, there is the need to increase cocoa production in order to generate more foreign exchange for use in developing the other sectors if the pace of the country's economic development is to be increased. It is for this reason that the government gives special attention to the cocoa sector through the Ghana Cocoa Board to ensure the sustenance of the sector.

1.2. Trends in Annual Cocoa Production

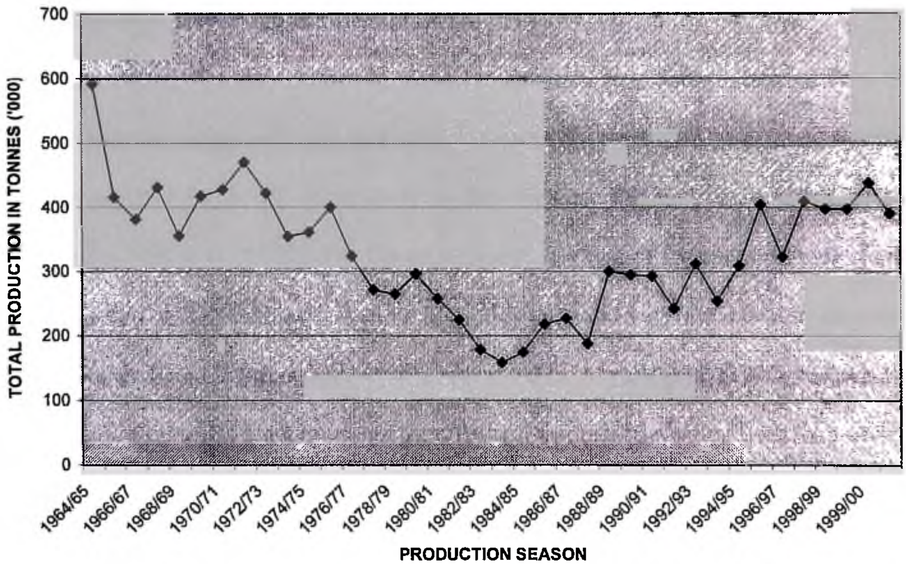
Past trends in annual cocoa production showed a gradual increase from 36.3 tonnes in 1891 to an all time peak of 580,000 tonnes in 1964/65 (COCOBOD, 1992), making Ghana the world's leading producer at the time. Ghana's share in the world cocoa output 1964/65 was around 33 percent. Throughout the late 1960s and early 1970s, growth declined, so that by 1975/76, when output stood at 390,000 tonnes, the country had a global share of only 26 percent. Output continued to drop thereafter reaching a low of 175,000 tonnes in 1984/85, which was a mere 9 percent of world production (Bronwyn, 1987).

Among the factors identified as being the causes of the decline in yield were the old age of farmers and their farms, illiteracy status of many farmers, which delay the degree of technology adoption with regard to disease and pest control as well as unfavourable land tenure system. Other factors include inadequacy of good planting materials for rehabilitation, inadequate husbandry practices, lack of credit facilities for the farmers and consistent absence of remunerative producer price (Bronwyn, 1987).

The Cocoa Services Division (1994) indicated that the age of most of the cocoa owned by farmers were 35 years and above. Production was declining because the area of young cocoa was 25 percent less than cocoa farms of 30 years old and above, which meant that most farms had either already exceeded their economic age or were close to their uneconomic stage. La-Anyane (1985) reported that the average age of the cocoa farming community in Ghana was between 50 and 60 years, and this affects productivity as the ability to undertake cultural practices is hampered, most especially where there are no farm hands or iterant farmers who are most often young and energetic. The Masdar Consultancy (1997) reported that the elderly farmers are less able to perform heavy tasks such as spraying and weeding, thus exposing the farms to pest and disease attack. An unfavourable land tenure system also leads to frequent land litigation, which tends to waste precious time needed for farm maintenance and results in the exposure of the farms to factors that lead to decline in production. The unavailability of good planting materials in sufficient quantities for the farmers also made rehabilitation of the old farms impossible as the old planting materials were found to be susceptible to most pests and diseases, and so failed to establish when used. The unavailability of credit facilities to the cocoa farmer also inhibited his ability to procure inputs and to hire enough labour to maintain the farms, thus, leading to a continuous decline in productivity of the farms at the time.

Finally, the absence of remunerative producer prices for cocoa caused a shift in the attention of most of the farmers from cocoa to other crops which had better returns at the time and so led to the neglect of most of the farms. These factors, among others, led to the declining trends in cocoa output witnessed in the late 1960s to the middle 1980s (Figure1.1).

FIGURE 1.1: TRENDS IN COCOA PRODUCTION FOR THE PERIOD 1964/65 TO 2000/01



Output again started picking up around the late 1980s after most of these problems had been addressed. A regular upward revision of the producer price attracted more of the youth into the cocoa sector, while the provision of sufficient good planting materials and technology packages by the Cocoa Research Institute of Ghana enhanced the rehabilitation of most of the farms. Output rose to 295,100 tonnes in 1985, which formed

12.3 percent of the world's total production. Ghana was however ranked the third largest producer at that time.

Since the 1990/91 season, cocoa production has been going through swings of a good year followed by a bad year. From an output of 293,400 tonnes in 1990/91, output fell to 242,800 tonnes in 1991/92 (10.7 percent of global production). Output again increased to 312,000 tonnes in 1992/93. By 1995/96, output had reached 403,900 tonnes forming 13.2 percent of global production (ICO, 1998/99; ISSER, 2001). Production currently hovers around 400,000 tons, which is between 12 to 13 percent of global production (ICO, 1998/99).

1.3. Efforts at Reversing the Declining Trends

Even though production has continued to increase, this increase has not been due to increase in output per unit area, but rather to either the expansion of existing farms or development of new farms, particularly in the Western Region where forest land is available (Appiah et al., 2000). The Cocoa Research Institute of Ghana undertook studies into the causes of the continuous decline in production and identified a drastic decline in soil fertility as the most important factor in recent times. Appiah et al. (1997) indicate that the removal of essential plant nutrients from the soil through harvesting over long periods without replenishment could be the major cause of decline in productivity on cocoa farms.

A study conducted by a Cocoa Board Task Force in 1994 revealed that about 50 percent of the cocoa farmers in Ghana were producing less than 256 kilograms per hectare and 23 percent produced between 256 kilograms and 384 kilograms per hectare (COCOBOD, 1994). Whereas the actual national average yield was about 400 kilograms per hectare, the actual average yield of the experimental farms from fertilised plots was over 1300 kilograms per hectare (Appiah et al., 1997). Comparative yields in Malaysia and neighbouring Cote d'Ivoire were 1700 and 800 kilograms per hectare, respectively (Appiah et al., 1997).

To turn around these declining trends in land productivity of cocoa farms, Ahenkora et al. (1981a) recommend that fertilisers should be incorporated into the rehabilitation exercise on mature cocoa farms. Various studies (Ahenkora and Appiah, 1996; Appiah, 1996) show high responsiveness of cocoa to fertiliser application. Gross yield of cocoa farms due to fertiliser application exceeded those of unfertilised plots by 61 percent in the first year, 99.8 percent in the second year and 116 percent in the third year (Appiah et al., 1996). The researchers concluded that the positive response to fertiliser application was an indication that absence of plant nutrients in the soil was a major cause of loss of cocoa farms in the Ashanti Region. They therefore advised that productivity in most of such farms could be restored with the use of fertilisers (Ahenkora and Appiah, 1996).

Convinced that the fertiliser application technology could solve the declining soil fertility problem, the technology was introduced to cocoa farmers in the old cocoa growing areas in the Ashanti and Eastern Regions at the beginning of the 1998 cocoa season. Since then, emphasis in cocoa extension has been on promoting fertiliser adoption.

1.4. Threat posed by the Cocoa Black Pod Disease

The expected increase in yield from fertiliser application is highly threatened by the black pod disease menace in the country and particularly, in the Ashanti Region. The disease continues to wipe out the benefits that are derived from the adoption of the fertiliser application technology due to the rotting of pods caused by the cocoa black pod disease. Asare-Nyarko (1972) reports that the black pod disease is the most important fungal disease of cocoa. For instance, in 1985, worldwide losses due to the black pod disease were estimated at £1,540 million (Evans and Prior, 1987).

In Ghana, losses on cocoa farms resulting from the cocoa black pod disease previously caused by only *Phytophthora palmivora* were estimated at 4.9 to 19 percent of output annually (Blencowe and Wharton, 1961; Dakwa, 1984). However, with the occurrence of the more virulent strain, *Phytophthora megakarya*, losses due to the disease in the affected areas have dramatically increased to 60 to100 percent (Dakwa, 1987; Padi and Owusu, 1998).

Meanwhile, Henderson et al. (1994), and Opoku et al. (1997) report that majority of Ghanaian cocoa farmers either do not treat their farms at all, or do only one or two applications per year, thus incurring heavy crop losses every year. These losses bring intense economic hardships to both small and large-scale farmers who depend on cocoa for a living. The high levels of pod losses due to the black pod disease warrant the use of appropriate technologies to manage the disease effectively and economically.

The seriousness of the problem thus prompted the government to announce in its 2001 budget, a programme of mass spraying of cocoa against pests and diseases (including the black pod) to begin in August 2001. This programme was again catered for in the government's 2002 annual budget in terms of funds. A committee set up by the Ghana Cocoa Board in 2001 to investigate the current problems of cocoa production with special reference to the spread and control of the Phytophthora pod rot strongly endorsed the government's intervention and recommended its continuation until the farmers were in a position to take over the programme themselves. The Committee pointed out that the losses were so heavy that failure to take immediate control measures would inevitably result in a further drastic reduction of Ghana's annual cocoa output (Asante-Kwatia et al., 2002).

Meanwhile, the sustainability of the programme is highly questionable considering the enormity of the work in terms of handling and administration of logistics by the secretariat and the problems emanating so far. A preliminary report by a team from the Cocoa Research Institute of Ghana (CRIG) to monitor the programme in the Eastern, Central and Ashanti Regions indicates that progress of work was slow and so most of the farms had not been sprayed, especially with respect to black pod control. These were attributed to problems such as shortage of fuel, delays in the distribution of chemicals and loss of morale among the spraying gangs (whose numbers were already small and so could not cope with the size of the area to be covered) due to delays in the payment of their wages for sometime (Asante et al., 2002). Thus, the eventual adoption of the control measures by the farmers themselves seems to be the best alternative for solving the problem of pod losses due to the disease caused by *Phytophthora megakarya.*

Asante (2002) has found the black pod disease control technology to be the limiting factor to the adoption of the high level management technological package. He therefore recommends that emphasis be placed on the cocoa black pod disease control technology. Adoption of this technology will help sustain the increased volume of pods on the trees, due to the fertiliser application, up to maturity. This will contribute to the realisation of the aim of increasing the yield of land under cocoa and the income of the cocoa farmer.

1.5. Problem statement

Resources continue to be invested in research in developing countries in order to strengthen their agricultural sectors and to ultimately increase output. Economists and Agricultural Economists have often supported this strategy with the conviction that innovations in technology more often than not accelerate agricultural production, which serves as an engine for development of the agricultural sector, which in turn contributes to the general economic development (Eicher and Staatz, 1984).

In-depth research has been conducted into the cocoa black pod disease menace by CRIG (Opoku et al., 1988; Padi and Owusu, 1998; Opoku et al., 1999). The appropriate technology has long been released to the cocoa farmers, to help turn around the downward trend of their productivity as a result of the high incidence of pod rot due to the black pod disease.

However, farmers continue to lose pods every year on a large scale due to the low levels of adoption and extent of use of the control measures. In 1992/93, decline in production was observed in almost all the cocoa growing regions. Losses recorded were 13.5 percent, 13.4 percent, 10.2 percent and 11.1 percent, in Ashanti, Brong Ahafo, Eastern and Central Regions, respectively (COCOBOD, 1993). This means the strategy to increase output per hectare of the cocoa farm is not yielding the desired results.

Consequently, there is the need to look at specific issues of concern related to the factors affecting the adoption of the cocoa black pod disease control technology. Some important research questions that arise therefore are:

1. What are the cocoa farmers' awareness and perceptions about the cocoa black pod disease and the recommended method of control?
2. What are the implications of the cocoa black pod disease control technology on production costs of the cocoa farmer?
3. What is the current extent of use of the cocoa black pod disease control technology?
4. What are the key factors (determinants), which influence the adoption of the recommended method of control of the cocoa black pod disease?

This study sets out to address these issues.

1.6. Objectives of Study

The general objective of the study is to investigate and determine why cocoa farmers in the Ashanti Region continue to lose pods despite the availability of a tried and tested control technology.

The specific objectives are:

1. To determine the awareness and perception of the cocoa farmers about the cocoa black pod disease and the recommended method of control.
2. To estimate the share of the cost of the technology (cocoa black pod disease control) in the total cost of production of cocoa in the Ashanti Region.
3. To determine the extent of use of the cocoa black pod disease control technology by cocoa farmers in the Ashanti Region.
4. To identify the key factors, which influence adoption of the cocoa black pod disease control technology by cocoa farmers in the Ashanti Region.

1.7. Relevance of Study

The identification of the factors affecting adoption of the technology and extent of its use in cocoa production will help provide the background information for Ghana Cocoa Board in planning and formulating strategies to urge farmers to control the black pod disease on their own. This will help ease the Government of the burden of having to organise funds to undertake a nationwide mass spraying exercise to control the cocoa black pod disease for the farmers. Knowing farmers' perceptions about the recommended control method will also help to eliminate the hindrances associated with the use of the technology, thus, leading to increased yield, which will eventually translate into increased income and in effect the farmers' welfare.

Researchers will also be guided in setting priorities in their future research programmes, especially with respect to modifying the methods of control of the black pod disease. It will also lead to the reaping of the full benefits of the funds put in by the sponsors (government) and the efforts put in by the researchers after the hindrances have been addressed and widespread adoption of the technology is attained on large scale.

The government will be encouraged to provide financial support for future research endeavours; and finally, the extension directorate of the Ministry of Food and Agriculture who are now in charge of cocoa extension will be equipped with the relevant information to plan and design extension programmes on black pod disease control.

1.8. The Study Area

The study covers four of the eight cocoa districts in the Ashanti Region namely, Mampong, Offinso, Tepa and Nkawie. These districts were selected because the megakarya pod rot, which warrants the adoption of the control technology, is virtually non-existent in the other four cocoa districts, namely Antoakrom, Fumso, Juaso and Obuasi districts[1].

Ashanti Region has vast cocoa farms grown in the forest zone, which has annual rainfall of around 1800 millimetres. The region is now the second largest producer of cocoa in the country and produced about 22% of the country's total national output during the 2000/2001 cocoa season (COCOBOD, 2002). The last cocoa tree stock survey conducted in 1997 gave the region an estimated area of 290,470 hectares under cocoa production out of a total estimated national cultivated area of 1.2 million hectares. The Region also commands about 25.6 percent of the total cocoa farmers in the country (COCOBOD, 1998). However, research indicates that the region has the lowest average

1. Personal communication, Mr J.B Dankwah, Regional Officer in charge of cocoa, Ashanti Region

yield of cocoa (Ministry of Finance, 1999).

Ashanti region as a whole was chosen for the study for the following additional reasons.

1. The incidence of the phytophthora pod rot is now assuming an alarming rate in the region, most especially, in the Mampong, Offinso and Nkawie Districts where the more virulent causal agent, *Phytophthora megakarya*, has long been identified. There is therefore the urgent need to find the problems that are hindering the farmers from adopting the recommended control measures in order to save the farmers from further pod loss in the region.
2. The level of cocoa production in the region has drastically gone down due to disease problems, the major one being the cocoa black pod disease. For example, the region's share in the national total cocoa production drastically reduced from 22% in the 2000/2001 season to 16.73% in the 2001/2002 season.
3. Lastly, the researcher has had the opportunity of working in the region for a period of ten years and so knows the region and the terrain, which are some of the attributes to help for easy data collection and cost reduction as well as making efficient use of the limited available time.

1.9. Organisation of Study

The study is organised into five chapters. Chapter two is devoted to the historical overview of the cocoa black pod disease and the recommended control technology in Ghana, a review of various adoption studies and methodologies of adoption. Chapter three outlines the theoretical background of models and analytical tools used in achieving the research objectives while chapter four deals with the analysis of the data, empirical results and discussions of the results. Finally, summary, conclusions, policy implications and recommendations to enhance the adoption of the cocoa black pod control technology form the core of chapter five.

CHAPTER TWO

LITERATURE REVIEW

2.1. Introduction

Cocoa has been the mainstay of the Ghanaian economy for nearly a century and its contribution to Gross Domestic Product, foreign exchange earnings and employment cannot be over emphasised. Yield levels in recent times are now greatly dependent on the adoption of recommended technologies, most especially with respect to the devastating black pod disease on which declining yield has been blamed and which poses a great threat to the industry (Asante-Kwatia et al., 2002). This chapter gives a historical overview of the black pod disease and the recommended technology for control. Literature is also reviewed on various adoption studies in order to identify the factors that are likely to influence adoption or non-adoption of the recommended technology. Also reviewed is literature on models used in the analysis of such adoption studies.

2.2. Overview of the Black Pod Disease in Ghana

2.2.1. Historical Perspective of the Black Pod Disease

The cocoa black pod disease is the most important fungal disease on cocoa (Asare-Nyarko, 1972), which mostly attacks the pods and causes them to rot before reaching maturity, thus rendering them no more useful for processing purposes. Cocoa pods attacked by the disease initially turn black in colour and eventually get rotten. The disease can attack the pods right from the developing stage up to the maturity stage. Every developing stage of the pod is therefore susceptible to attack by the disease.

Four different species of phytophthora (a fungus) are known to be pathogenic on the cocoa crop and these are *Phytophthora palmivora*, *Phytophthora megakarya*, *Phytophthora capsici* and *Phytophthora citrophthora*. Two of these, *Phytophthora palmivora* and *Phytophthora megakarya*, have been identified as the causal agents of the disease in Ghana (Brassier and Griffin, 1979; Kellam and Zentmyer, 1982; Dakwa. 1987; Opoku et al., 1999). It is generally believed that until recently, black pod disease problems in Ghana were originally caused by *Phytophthora palmivora* alone, which is at the moment found in almost all the cocoa growing regions in the country (Dakwa, 1974). Asare-Nyarko (1969) indicates that *Phytophthora palmivora* was first described in India on borassus palm, a plant that is indigenous to the savannah woodlands of Ghana. Literature indicates that it is not clear as to exactly when the cocoa black pod disease first appeared in Ghana, but according to Opoku et al. (1999), it is apparent that the disease has been in the country for a long time, perhaps, ever since the crop was commercialised. One of the causal pathogens, *Phytophthora palmivora*, is believed to be indigenous to the forest soils of Ghana (Dakwa, 1974).

Until 1985, black pod disease was not a major concern of many farmers since yield losses in many parts of the country were generally believed to be very low. History indicates that research on phytophthora diseases on cocoa was begun in 1926 (Tharold, 1974). Wharton (1962) suggests that black pod disease caused by *Phytophthora palmivora* appeared in the latter part of the 19th century when cocoa was introduced into Ghana. The pod rot situation in Ghana changed when the more virulent phytophthora strain, megakarya, infected the pods. There are differences in opinion as to when *Phytophthora megakarya* infection first appeared in Ghana (Akrofi, 2000). The first report of its outbreak was in 1985 on a well-maintained farm at Bosomponso in the Akomadan cocoa district of the Ashanti Region.

2.2.2. Spread and Current Incidence of the Disease

Circumstantial evidence according to Akrofi (2000), suggests that *Phytophthora megakarya*, the virulent pathogen might have started in the Volta Region of Ghana from where it got to the Akomadan and Bechem areas. Dakwa (1975, 1976, 1977 and 1978) has consistently shown that the Volta Region had the highest black pod disease incidence than any part of the country. Opoku and Owusu (1995) suspect the transmission of the megakarya pathogen to Ghana by the returnees expulsed from Nigeria in 1983.

Dakwa (1987) estimates the area of infection in the Akomadan and Bechem Districts to be about 20,250 hectares. However, a limited survey carried out from 1990 to 1992 (Luterbacher and Akrofi, 1993) showed that outbreak of *Phytophthora megakarya* were limited to the Akomadan cocoa district in the Ashanti Region and Bechem and Berekum in the Brong Ahafo Region. Opoku et al. (1995a) have recently shown that *Phytophthora megakarya* is found in all the cocoa growing districts in the Volta Region. Newly infected districts include Offinso, Tepa, Nkawie and Kunsu, all in the Ashanti Region. Despreaux et al. (1987) estimates the disease incidence in Cameroon to be as high as 80 percent while in Ghana, disease incidence in *Phytophthora megakarya* infected areas differs according to length of time of farm infection. It could be as high as 100 percent in the old infected farms and 60 to 80 percent in newly infected farms (Dakwa, 1988). Losses due to *Phytophthora palmivora* are however lower compared to that of *Phytophthora megakarya*. A survey of the six cocoa growing regions in Ghana during the 1970s estimated the annual disease incidence attributed to *Phytophthora palmivora* to be between 18 and 27 percent. Dakwa (1987) estimates that the megakarya pathogen is spreading at a rate of about 3.2 kilometres (2 miles) per year.

2.2.3. Economic Importance of the Black Pod Disease

Asare-Nyarko (1972) indicates that phytophthora pod rot is the most important fungal disease of cocoa in West Africa. The black pod disease is said to be cosmopolitan in distribution, occurring wherever cocoa is grown in Ghana (Akrofi and Opoku, 2000). Before the advent of *P. megakarya*, pod losses due to the disease were generally low, ranging from 4.6 to 19 percent (Blencowe and Wharton, 1961; Dakwa, 1984). The occurrence of *P. megakarya* in Ghana however, has considerably changed the black pod situation in the country as pod losses in affected areas range from 60 to 100 percent (Dakwa, 1987). The economic and social implications of the destructive nature and the alarming rate of spread of *P. megakarya* are already evident in the country (Akrofi, 2000). Farmers are reported to have abandoned cocoa cultivation in Akomadan and Bechem districts and moved into other ventures such as tomato and maize production. The morale of cocoa farmers in *P. megakarya* infected areas is very low and enthusiastic farmers have been forced to migrate to non-infected areas to set up new farms to the detriment of the environment (Akrofi, 2000). The disease has been a major player in the decline in cocoa production in the country, as infected pods are declared unusable.

2.2.4. Recommended Control Technology for the Black Pod Disease

The extremely wide variation in pod losses due to the megakarya black pod disease warrants that best approaches are used to effectively and economically manage the disease. Before the advent of the *Phytophthora megakarya* strain, phytosanitary practices were the principal methods of control of the black pod disease in Ghana. This method includes the judicious manipulation of shade on the farms to allow for the full penetration of the sun's rays to reduce dampness of the environment, frequent brushing to control weeds and wider plant spacing so as to allow for the free circulation of air in the farm and early removal of infected pods to prevent further spread to healthy pods, especially in times of high humidity. These management practices reduce humidity and limit the incidence of black pod and also result in satisfactory and economic control of *Phytophthora palmivora* (Asare-Nyarko, 1969). However, the presence of the more virulent strain of the fungus, *Phytophthora megakarya*, prompted the development of new strategies to combat the disease as the cultural practice was found to be inadequate and not effective enough to control the disease. Thus chemical control technology, tried and tested by the Cocoa Research Institute of Ghana, was released to the farmers.

The recommendations for the chemical control technology involve spraying to protect the apparently healthy pods with copper based fungicides, with or without metalaxyl, at three weekly intervals, resulting in about 7 to 9 applications per year during the rainy season (Hislop and Park, 1960). Opoku et al. (1998) have shown that a frequency of four weekly sprays leading to 4 to 7 applications a year can still achieve good control of the megakarya with the use of the new fungicides, which have systemic properties at the recommended dosage. The chemical control measures involve spraying to coat the pods with a solution of either kocide 101, caocobre sandoz, nordox 75, champion or ridomil 72+, which are all fungicides (CRIG, 1995). Only pods are targeted with the chemical, thus trees without pods or chereles are not sprayed. Spraying is done using pneumatic spraying machines (hand sprayers), often carried on the back.

This technology, which has proven to be effective against the *P. megakarya* pod rot on experimental farms and on-farm demonstrations, is still not being adopted as expected though cocoa farmers continue to incur heavy crop losses every year (Opoku et al., 1997). This situation prompted the government to undertake mass spraying of cocoa farms in the country on behalf of the farmers from the beginning of the 2001/2002 cocoa seasons. Factors influencing adoption of the technology therefore need to be reviewed and the possible factors serving as hindrances to adoption of the black pod disease control technology identified for redress. This will pave way for increased adoption of the technology, which will eventually translate into increased national output of cocoa in Ghana.

2.3. Overview of Adoption Studies

2.3.1. Definition and Concepts of Adoption

For purposes of rigorous analysis, a precise definition of adoption is needed. Such a definition needs to distinguish between individual (farm level) and aggregate adoption. According to Feder et al (1985), final adoption at the level of individual farmer is defined as the degree of use of new technology in long-run equilibrium when the farmer has full information about the new technology and its potentials. This definition relates to Schultz's (1964) contention that the introduction of new technologies result in a period of disequilibrium behaviour where resources are not utilised efficiently by individual farmers and learning and experimenting lead the farmer towards new equilibrium levels. This definition implies that adoption has two separate components: a time component indicating length of time the technology has been used, and an intensity of use component indicating appropriateness of its use. Such long-run information is seldom obtained, however, and the adoption of a technology is generally reduced to a binary variable indicating use of technology or not (Kaliba et al., 2000).

Farmers generally are assumed to respond to innovation adoption individually. There is the group that respond partially, others are quick adopters while yet another group may not respond at all. Adesina and Zinnah (1993) for instance, distinguish between two types of technology adoption and diffusion, which are the adoption-diffusion paradigm and the economic constraint paradigm. Though both assume that the technologies' characteristics determine their adoption and diffusion, these are included only in few empirical models (Adesina and Zinnah, 1993; Adesina and Baidu-Forson, 1995; Fliegel and Kivlin, 1996). A distinction is made between diffusion and adoption in most of the literature. Diffusion is considered to begin at a point in time when an innovation is ready for use, and the main focus of diffusion is to explain how the innovation or technology is made available to the potential users (Jabbar et al, 1998). The earliest users of the technology may be called innovators and the diffusion process involves the spread of the innovation to the rest of the population. On the other hand, adoption studies consider the behaviour of individuals in relation to the use of the technology, particularly the reasons for adoption at a point in time, or the reasons for time adoption for individual users, are of primary interest. Diffusion may be viewed as a dynamic process over time, relative to adoption (Stoneman, 1983; Thirtle and Ruttan, 1987).

Negatu and Parikh (1999) also categorise paradigms or conceptual models employed to explain the decision of small farmers to adopt new technology into three groups: (i) the innovation–diffusion model; (ii) the economic constraints model; and (iii) the technology characteristics-user context model. The innovation-diffusion model, also called transfer-of-technology (TOT), follows from initial works of Rogers (1962). The model states that technology is transferred from its source (research system) to final users through agent medium (extension system) and its diffusion in potential user-communities depends on the personal characteristics of the potential individual user. The model assumes that the technology is appropriate for use unless hindered by lack of effective communication.

The economic constraints model, also known as the factor endowment model, is based on the central assumption that the distribution of resource endowments among potential users in a region determines the pattern of adoption of the technological innovation. The model assumes that market prices (or surrogate prices induced by policy and institutional interventions) reflect relative scarcity of factors, implying the existence of (or need for) well performing markets and price policies (Hayami and Ruttan, 1985).

The technology characteristics-user's context model integrates approaches, which assume that characteristics of a technology underlying user's ecological, socio-economic and institutional contexts play the central role in the adoption decision and diffusion process (Biggs, 1990; Scoones and Thompson, 1994). When farmers are not involved in the technology generation process, awareness and knowledge about the new technology precedes any adoption decision (Jabbar et al., 1998). Several authors have emphasised the importance of information gathering and updating information through learning-by-doing in the adoption process. There may be a lag between the time when farmers first hear about an innovation and the time they adopt it (Tsur et al. 1990; Feder and Umali, 1993; Fisher et al, 1996). Empirical verification of the linkage between learning and adoption and what future influences such linkages have, is found to be rare. Saha et al. (1994) have developed and tested a model in which producers' knowledge about a new technology (phase I) determines the decision to adopt (phase II), which in turn determines intensity of adoption (phase III).

The process of learning and adoption may actually involve more steps and complexities. Any adoption decision is preceded by a period of awareness and learning. Initially, only limited amount of information may be available or only a limited amount of information may be digested. The information includes knowledge about how the technology functions and where and how to get access to it. The optimal level of information is reached when information acquired over a period of time reaches a threshold level at which a decision can be made.

These definitions appear simplified as most of the recent technologies often come out in packages. For instance, the recommended technologies under the high-level management for cocoa production were considered as a package, which the cocoa farmer must adopt together. Farmers who perform all the practices under the high-level management and at the recommended intensity are considered adopters while those who perform part but not all are said to be non-adopters. However, each technology under the high-level management technology has its peculiar characteristics and requirements and so are differently influenced socio-economically, technically and institutionally in their adoption. Consequently, though the package for cocoa production may complement each other, the black pod disease control technology can be independently adopted of the other components of the package. In this study therefore, an adopter is defined as a farmer who sprayed his/her farm against the black pod disease at least four times a year for a minimum of two continuous years prior to the mass spraying exercise.

The adoption of a new agricultural technology is important for evaluating the impact of agricultural research investments (CIMMYT, 1993; Collinson and Tollens, 1994), and for guiding technology development to satisfy the needs of the clients. Technology adoption according to Sanginga (1998), brings potential impact at the farm household level.

In a wide sense, adoption studies are intended to analyse the process of farmer decision-making in adopting new technologies. Such studies, according to Kalyebara (1999), usually involve identification of factors which constrain or enhance adoption (determinants), spatial and temporal patterns of adoption (adoption pattern), when various types of farmers adopt (rate of adoption), the extent to which a technology is applied by farmers (extent of use) and which farmers do not adopt and why.

2.3.2. Determinants of Adoption

The adoption of innovations in agriculture has been widely studied since the pioneering work of Griliches (1957) on adoption of hybrid corn in the USA. The majority of recent adoption research (Tsur et al., 1990; Leathers and Smale, 1995; Feder and Umali, 1993; Saha et al., 1994; Marsh et al., 1995; Rogers, 1995) have been concerned with answering the questions: (a) what determines whether a particular producer adopts or rejects an innovation, and (b) what determines the pattern of diffusion of the innovation through the population of potential adopters. Lindner (1987) states that overall, despite numerous studies, the results of research in this field have been disappointing as most of the statistical models developed have low levels of explanatory power, despite long lists of explanatory variables.

Furthermore, the results from different studies are often contradictory regarding the importance and influence of any given variable (Amir et al., 1999). Factors that influence farmers' adoption are mostly the conventional (traditional) ones: resource endowments, socio-economic status, demographic characteristics and access to institutional services such as extension, input supply, markets, credit, etc (Negatu and Parikh, 1999). Feder et al. (1985) state that farmers' adoption behaviour, especially in low-income countries, is influenced by a complex set of socio-economic, demographic, technical, institutional and bio-physical factors. Small-scale farmers' decisions to adopt or not to adopt agricultural technologies depend on their objectives and constraints, as well as cost and benefit analysis. Farmers will adopt only technologies that suit their needs and circumstances (Ntege-Nanyeenya et al., 1997). Studies on the effects of conventional factors on adoption are extensive and numerous (Feder et al., 1985; Feder and Umali, 1993).

Getahun et al. (2000) identify the various socio-economic, institutional and technical factors influencing adoption of improved maize varieties in Ethiopia. Their result indicate that membership of organisation, livestock ownership, educational level and access to credit have significant influences on the adoption decisions of small-scale farmers in the country. Livestock ownership was used as a proxy for off-farm income, which is a source of higher income for procurement of inputs. Million (2001) in a more recent study on determinants of fertiliser use on maize and tef in Ethiopia, also states that farmers' adoption decisions are significantly influenced by the age of the farmer, availability of credit, frequency of contact with extension agents, livestock ownership and off-farm income.

Mussei et al. (2001) in a study on adoption of improved wheat technologies in Tanzania, indicated that adopters were more literate, slightly younger, had larger family labour, had smaller farm sizes, had more access to credit, had access to more off-farm income, but had fewer years of farming experience. Semgalawe (1998) in a study to explain household adoption behaviour towards the use of improved soil conservation measures in Tanzania concluded that farmers' decision whether to adopt or not is dictated by socio-economic and institutional factors. These include family labour, farm size, off-farm income, household's educational level, household's economic rank, institutional support (credit), level of extension visits and membership of labour sharing group. Lopez and Requena (2002) consider as important in adoption, factors such as farmer characteristics (age, education, experience in farming and contact with information source) and farm attributes (size and yield). Ngatia and Kabara (1976) in Kenya observed that institutional factors (input constraints, extension influence, and credit) and farmer characteristics (including off-farm employment) were major determinants of adoption of coffee production recommendations.

Also in Kenya, Njagi (1980) concludes that availability of cash (credit), access to inputs such as manure, which are all institutional factors, affected adoption of soil fertility management recommendations. Kamau (1980) reports that adoption of weed control recommendations was influenced by institutional factors such as availability and cost of labour and cash flow constraints. Other more general studies like one by Green and Ng'ong'ola (1993) conducted in Malawi reported institutional factors as the main factors affecting adoption of fertiliser recommendations. Kebede et al. (1990) on the other hand, observed farmer characteristics (farm size, family size, farm income and educational level) and institutional factors such as access to information as having significant effects on fertiliser adoption.

Adejobi and Kormawa (2002) also identify institutional factors (inaccessibility to inorganic fertiliser, extension services, etc) and farmer characteristics such as membership of cooperative society and ownership of livestock as determinants of manure use in Nigeria. Degu et al. (2000) find off-farm income, availability of labour, use of credit and being a contact farmer (extension) to be significant in fertiliser adoption; while credit, extension and membership of an organisation were found to be determinants of improved maize adoption in Ethiopia. Other studies have also identified farmer characteristics and institutional factors associated with adoption (Daberkow and McBride, 1998; Khanna, 2001; Croppenstedt and Demeke, 1996).

In the case of technologies on disease control, it is evident from the literature that very little is known about the characteristics and farm level factors (predictors) contributing to or affecting adoption. Nell (2000) in a study on the adoption of livestock veterinary technologies identifies educational level, age of farmers, membership of association, social status and access to roads as the influential factors.

In a nutshell, empirical studies on agricultural technology adoption generally divide a population into adopters and non-adopters (potential adopters), and analyse the reasons for adoption or non-adoption at a point in time principally in terms of socio-economic characteristics of adopters and non-adopters, as well as technical and institutional factors (Thirtle and Ruttan, 1987; Feder and Umali, 1993). The underlying characteristic of these factors is that they are hypothesised to affect the demand for the technology. Overall, the factors that determine a household's decision to use a new technology such as cocoa black pod disease control fall into socio-economic or household-level factors, market or institutional variables and technical variables.

2.3.3. Socio-economic Factors Affecting Adoption

Age: Age is one of farmers' characteristics that are important in examining adoption studies and may influence adoption in one of several ways. Age of head of household has been found to be a significant factor affecting the use of new technologies, but of contradictory impact in some research; and even insignificant in others. According to CIMMYT (1993), younger farmers are more likely to adopt a new technology than older generation, perhaps because they have been exposed to new ideas. Onu (1991) also indicates that use of farm information sources decreases with increased age of farmers, which implies young farmers are more alert to obtaining information from sources that discuss more ways of improving their vocation than older farmers. Kaliba et al. (2000) on the other hand, conclude that older heads of household were more likely to use fertiliser in Tanzania. Khanna (2001) finds similar results. Several other studies on fertiliser use in

Sub-Saharan Africa found age to be significant but of varying effects (for example Green and Ng'ong'ola, 1993; Nkonya et al., 1997).

Educational Level: Education has almost been heralded as a cornerstone of the modernisation process in agriculture and research work indicates that adoption is strongly related to the educational level of respondents (Lin and Jeffres, 1998; Abdelmagid and Hassan, 1996). Better-educated farmers are more likely to adopt new technologies and have access to extension services (IFPRI, 1995). Educational level of household head is therefore, assumed to have an important, positive impact on the adoption and use of new technologies. Pickney (1995) discusses the example of a World Bank policy study on Uganda, which stated, "raising educational levels of farmers enhances agricultural productivity through technology adoption". Saito and Weideman (1990) report that household's access to agricultural extension and their ability to comprehend and use technological innovation is compromised when they lack education.

As technological innovation spreads more widely within a country, the importance of education to farm production ought to be more apparent (Sharada, 1999) and that there are possible benefits of schooling in agriculture in terms of increasing efficiency and the adoption of innovation. Hussein and Byerlee (1995) also note that evidence is mounting (for Asia at least) that returns to education in agriculture may be as high as for urban wage earners. Dercon and Krishnan (1998) using panel data in six sites in Ethiopia conclude that the educated were able to take better advantage of opportunities of new innovations to increase output and consumption. The results of research by Nkonya et al. (1997) show education to be an important factor in the household's decision to adopt improved seeds. Sain and Martinez (1999) also find education to be significant but of different effects in a study of households in Guatemala; while level of education of household head was found to have a negative effect, participation in associations (another form of education) had a positive effect on adoption of improved maize seeds. Educational level is generally, hypothesised to have significant positive effects on adoption of technology as have been revealed by various adoption studies (Admassie and Asfaw, 1997; Appleton and Balihuta, 1996; Rosenzweig, 1995).

Farm Size: This will generally have a positive effect on a household's decision to adopt and use a new technology (Kherallah et al., 2001; Zepeda, 1994). Households with larger cultivated areas will tend to have more productive assets and fewer credit constraints than smaller ones. Doss and Morrison reported larger farm sizes to positively affect the use of both modern varieties of maize as well as fertiliser in Ghana. Land area cultivated also positively affected the results observed by Sain and Martinez (1999) in Guatemala. Both Rochin (1973) and Bose (1974) conclude that small farmers in Bangladesh were at a disadvantage in obtaining scarce credit, which negatively affected their adoption decisions. Other studies have found farm size to be negatively correlated with technology adoption. Feder et al. (1985) and Nkonya et al. (1997) find farm size to be significant, but negatively related to improved maize seed use, indicating that households with smaller cropped areas used improved maize seed more intensively than did larger farms in Tanzania.

Household Labour Size: Labour constraints may also affect a household's ability and willingness to adopt and use a new technology (Feder et al, 1985). It is for this reason that labour size of households is typically hypothesised to have a positive effect on a household's decision to use a new technology. Croppenstedt and Demeke (1996) and Green and Ng'ong'ola (1993) suggest this to be the case. Doss and Morris (2001) report the number of adult males in a household to significantly affect use of improved varieties of maize in Ghana as labour constraints in terms of cost and availability would have been solved. Shields et al. (1993) also indicate that the most persistent finding in adoption studies is the positive effect of labour availability from the household on the probability of increased technology adoption

Membership of Cooperative Society: Members of an organisation (farmer groups) are put in a privileged position with respect to other farmers, in terms of their access to information on new technologies as well as to credit facilities. Cooperative societies most often provide credit to their members, especially for productive purposes and this tends to relief them of their financial constraints. The result is that members are enabled to acquire the necessary inputs for the application of an innovation and thereby influencing adoption positively. Using a logit framework, Saito et al. (1994) find membership of a cooperative society to be positively and significantly related to adoption of new bean varieties by both female and male farmers in Kenya.

Off-Farm Income: This is typically seen as significant in the decision of households to use new technologies. Households with lower levels of off-farm income or poor access to credit are less likely to be able to afford newer, potentially riskier and cost intensive technologies (Feder et al., 1985). Income outside the farm will help ease financial constraints and contribute to easy acquisition of inputs. In earlier studies in West Africa, Kelly (1988) and Reardon et al. (1994) found off-farm income to influence technology adoption positively. Braun et al (1994) also observe that a higher proportion of off-farm income in total income encourage farmers to procure inputs required for the application of an innovation.

Gender: Different rates of technology use are typically observed between male and female heads of households (Doss and Morris, 2001). The gender of the head of household may influence the use of a new technology for various reasons. Male and female heads of households may have different levels of access to extension, credit or to transportation assets. Some cultural beliefs also differentiate the roles of males and females in the farm operations and in effect their adoption of the black pod control technology. Mehra (1994) states that in Sub-Saharan Africa including Ghana, there is a gender division of labour. However, gender of household heads has been found to be insignificant in some studies (Croppenstedt and Demeke, 1996; Doss and Morris, 2001). Despite these results, Doss and Morris do suggest that gender may play a role through other institutional constraints such as access to extension, credit and other resources.

Working Experience: Experience is generally seen as a form of acquired wealth of knowledge, which has similar effects like education. With experience comes a build up of confidence (Kebede, 1992), which tends to reduce uncertainty and risk aversion and so increases the farmers' decision-making skills and willingness to adopt innovation.

Farm income: The level of farm income is an important determinant of the farmer's purchasing power and ability. Farmers' wealth measured by farm income as proxy relaxes the credit constraint and increases the farmer's ability to use a new technology (Million, 2001). Higher proceeds from the farm will enable the farmer to acquire the necessary inputs required for applying the technology, thus relating positively to adoption.

2.3.4. Institutional Factors Affecting Adoption

Distance to source of inputs: A measure of the distance the farmer has to cover before procuring inputs will have great impact on the farmer's willingness to apply an innovation. The additional and extra costs (transportation) to be incurred in acquiring inputs from distantly located input stores will serve as a disincentive for adopting an innovation (Adesina, 1996). Previous studies in West Africa by Prudencia (1983) and Matlon (1994) indicate that adoption is negatively related to distance to sources of inputs. Access to inputs serves as the engine for applying an innovation. Farmers are negatively influenced if the inputs required for using an innovation are not easily accessible in terms of location. Inaizumi et al. (1999) conclude from their findings that access to market for inputs is critical in farmers' adoption of new varieties, which corroborates recent findings by Adesina et al. (1997); Adesina and Baidu-Forson 1995); and Sanginga (1998).

Access to Credit: One obvious reason for differential adoption rates in many regions is the credit constraint. Where credit for small farmers is severely limited, they may not be able to adopt innovations at the same rate as larger farmers. Ampofo (1990) note that credit availability is an important factor in cocoa production since traditional methods of communal assistance in the operation of cocoa farms in Ghana is no more existent and labour hiring, which demands ready cash payment or some line of credit has taken its place. Bhalla (1979) in a study of Indian agriculture indicates that small and large farmers differed in the reasons for not using fertiliser in 1970-71. Lack of credit was a constraint for 48 percent of small farmers. Similarly, in a study of high yielding variety adoption by Pakistani farmers, Lowdermilk (1972) indicates that majority of small farmers reported shortage of funds as a major constraint in the fertiliser application technology. Access to credit was found to be significantly associated with fertiliser use in Nepal (Shakya and Flinn, 1985). Green and Ng'ong'ola (1993) detect access to credit to be significant in the use of fertiliser in Malawi.

Access to Extension Service: Access to farm level extension increases productivity through adoption of innovation (Trudy et al., 2001). As argued by Birkhaeuser et al. (1991) and Evenson (1998), agricultural extension represents a mechanism by which information on new technology, better farming practices and better management can be transmitted to farmers. Extension contact is therefore found to be positively related to productivity through innovation adoption as was observed in Kenya by Bindlish and Evenson (1993, 1997) and Seyoum et al. (1998).

Price of Inputs: Input price has been found to have a negative effect on adoption by many researchers (Kheralla et al., 2001; Adhikary, 1994). This is based on economic theory of demand, which indicates that as the price of a good increases, its demand falls. The higher the cost of inputs required for applying a technology, the lower the adoption is expected to be. Kherallah et al. (2001) report that market price of fertiliser had a negative effect, as economic theory would suggest, on fertiliser use in Benin.

2.3.5. Extent of Use of Technology

The extent of use of a technology is defined as the level of use of the given technology by an individual after adoption has taken place. Thus, the concept of extent of use demands a first step adoption. This may refer to the extent of land area being committed to the technology application after adoption, or the number of applications as against the technology recommendations after adoption. Extent of use may also be defined in terms of an index. Pisanelli et al. (2001) estimate the extent of use of improved tree fallows in Western Kenya and defined an index of adoption (use) as the area committed to an innovation as a percentage of the total area that a full adopter would commit. This index is sometimes used to denote the extent of adoption of an innovation after adoption. The adoption index was employed to investigate the extent of adoption of the cocoa black pod disease control technology in the study area. Generally, studies on extent of use of adoption are rare in the adoption literature (Pisanelli et al., 2001). Hildebrand and Poey (1985) also worked on the extent of use of technology in Colorado and used an index for the estimation.

2.3.6. Farmers' Perceptions About Technology

Perception has been differently defined by various researchers (Crider et al., 1989; and Morris, 1985), all of which border on the subjective assessment of information by an individual using the senses. Wortmann et al. (1988) however, define perceptions as the process whereby the brain gives order and meaning to the sensation it receives. Thus the primary function of perception is to help individuals make sense of information received.

Farmers' decisions to adopt a new agricultural technology in preference to other alternative (old) technologies depend on a number of complex factors. One of the factors is farmers' perception of the new technology vis-a-vis that of the existing technology. The importance of commodity-attribute perceptions, according to Adesina and Baidu-Forson (1995), has long been of interest to social scientists investigating agricultural technology adoption decisions. Based on evidence in consumer demand theory that demand for a product (in this case, technology) is significantly affected by the consumer's perceptions of the product's attributes (Lin and Milon, 1993), some adoption studies have included farmers' subjective assessment of technology attributes as explanatory variables (Nowak, 1993; Adesina and Zinnah, 1993; Adesina and Baidu-Forson, 1995). On the basis of knowledge at a point in time, a perception or belief is formed about the technology and a decision to adopt, reject or defer may be taken. The impact that farmers' perceptions of the characteristics of different varieties (food quality, yield, tillering capacity, etc) have on the adoption of modern sorghum and rice varieties has been demonstrated by these researchers.

Perception studies present a useful dimension for identifying the ways by which farmers evaluate the real attributes of new technologies before adoption, and to identify factors that bring about differences in perception formation among farmers (Negatu and Parikh, 1999). Awareness of the factors that influence perceptions of farmers would also facilitate the enhancement of the development and transfer of appropriate technologies. Asfaw et al. (1991) consider incorporation of farmers as participants and their perceptions and preferences as important elements in the technology generation process and essential for generation of appropriate technology.

Most adoption studies have concentrated on the effects of farmers' characteristics on adoption decisions (Feder et al., 1985; Feder and Umali, 1993; Croppendstedt and Demeke, 1996; Mussei et al., 2001). They compare farmers who have adopted or rejected a certain technology at a point in time, but say little about the influence of technology characteristics or attributes on adoption and diffusion. The constraints on adoption of the available technologies according to Negatu and Parikh (1999) can be categorised into three general sets: non-performance of the recommendations to the level of farmers' expectations and needs, when compared to their traditional methods; the problem of non-compatibility of the technologies with the ecological and other resource endowments of small farmers, which is often compounded by the risk-averse attitudes of farmers; and inadequacy of institutional support services. Meanwhile, this knowledge would improve planning for research and development considerably. Knowing the perceptions of the farmer about the characteristics of the technology helps to identify which characteristics new technologies should possess to become quickly and widely adopted (Anthony and Anderson, 1991; Alston et al., 1995). It is thus an important guide to researchers in the development of agricultural technologies.

This study evaluates the farmers' awareness and perceptions about the cocoa black pod disease and the recommended control technology in order to advise researchers and policy makers. This is an explanation of technology adoption based on impact of technology characteristics, which specifies technology adoption as a function of technology characteristics, farming circumstances as well as farm and farmers' characteristics.

2.3.7. Characteristics of Innovation Affecting Adoption

Extensive work in innovation-adoption has highlighted the key role of perceptions in adoption of innovations (Swanson et al, 1984; Rogers 1995; Agarwal and Prasad, 1998). Rogers (1995) indicates that the characteristics of an innovation, as perceived by potential users and not as seen by experts, have great influence on the adoption of innovations. A decision to adopt is predicted on the technical characteristics of the innovation. Some innovations are adopted rapidly than others due to the fact that farmers perceive them to have different characteristics. As noted earlier, there is an abundance of adoption literature, which has identified many factors that may influence the adoption process. This study emphasises the farmers' personal subjective perceptions of the technology for cocoa black pod disease control in terms of its relative advantage, compatibility, complexity, trialability and observability. These factors all influence the adoption decision by influencing the farmers' subjective perceptions, uncertainty and attitudes (Amir et al., 1999). These factors may somewhat be interrelated but are conceptually distinct (Rogers, 1995).

Relative Advantage: Relative advantage measures the extent to which the innovation is seen as offering an advantage compared to the old and previous ways of performing the same task (Adesina and Seidi, 1998; Agarwal and Prasad, 1998). It is the degree to which an innovation is perceived as better than the idea it supersedes (Melkote, 1997; Rogers, 1995). The relative advantage is captured in the profitability, low initial cost, level of reduction in discomfort, savings made in time and effort as well as the expectation of reward dimensions.

Byerlee and de Polanco (1982) state that relative profitability of technologies is expected to be an overriding factor in farmers' decision making. Roberts et al. (2000) indicate that the key to farmer adoption of site-specific farming is the profitability of the technology. Farmers will adopt technologies that promise high returns to investment relative to traditional alternatives. High relative profitability accelerates the speed of adoption and also leads to a high ceiling of adoption.

Decrease in discomfort is associated with the risks attached to the technology application. The fact that the use of some spray chemicals can cause skin problems to farmers accounts for the low adoption of such chemicals. Initial costs determine adoption decisions especially in the case of the resource-poor smallholders. They become a limiting factor for adoption since farmers cannot adopt a profitable technology if initial capital outlay is high and capital is scarce. This means if farmers are resource poor and access to capital is limited, profitable technologies might not be adopted if they require a high capital outlay. It is postulated that technologies with high relative investment index will be adopted more slowly than technologies with low relative investment index.

Complexity: Technologies differ in their relative management complexities. Leaning against systems theory, complexity is defined as a function of a number of activities that have to be performed to adopt and to use a technology weighted with the difficulty of these activities (Willke, 1991). Agarwal and Prasad (1998) define complexity as the ease of use and it captures the degree to which a potential adopter views usage of the target technology to be relatively free of effort. Melkote (1997) on the other hand, sees it as the degree to which an innovation is relatively difficult to understand and use. Complexity is high when farmers have to carry out many activities to establish and to run a technology (Batz et al., 1999). Relative complexity of an innovation is higher the more complex a new technology is in relation to the traditional technology. Technologies with high relative complexity diffuse more slowly than others and will finally reach a lower ceiling of adoption.

Trialability: Roger (1995) and Melkote (1997) define it as the degree to which an innovation could be tried on a limited basis. Farmers are more willing to adopt a technology after having given it a trial on their own to be certain of the implications that go with the application of the technology, especially in terms of costs. Costly and complex innovations that cannot be taken a little at a time stand the chance of not being adopted. Rogers (1983) finds trialability to be positively related to adoption rate of an innovation.

Observability: The degree to which the results of an innovation are visible to the adopter and others is observability. Farmers are observed to learn much by observing the results of their colleagues and from trials on experimental farms. The easier it is to see the advantages of an innovation, the more likely it is to be adopted (Melkote, 1997). Rogers (1962) demonstrates with the pre-emergent weed killers that are sprayed on a field before the weeds emerge from the soil. The adoption rate was found to be slow by Mid-Western farmers, in spite of its relative advantage because there were no dead weeds for the farmer to show his neighbour.

Hiruschka (1961) rates farm innovations into four categories of observability in an investigation of the role of demonstration farmers in diffusing new ideas in German villages. The ideas, which were rated as more communicable, for instance haymaking, diffused more readily from the demonstration farmers to surrounding villagers than less communicable techniques like keeping of farm records. The highly visible and spectacular yield results of a newly introduced maize variety, Cuban Yellow Corn, in Bolivia led to a rapid adoption rate in 1952 (Rogers, 1962).

All five perceptions are relative concepts and not innate attributes of the innovation, and can be perceived differently by different individuals. People's perceptions may affect their adoption far more than the technical characteristics of innovations. Innovations that are perceived as having greater relative advantage, compatibility, trialability and less complexity will be adopted more rapidly than other innovations (Rogers, 1995). Perceptions are influenced by personal characteristics, extension delivery, values, beliefs, attitudes, and objectives of assessment of the characteristics of the innovation (Adams, 1982). They play different roles in adoption for different individuals (Agarwal and Prasad, 1998).

2.3.8. Methodologies Used for Adoption Studies

Literature indicates that econometric models are the most appropriate for the analysis in adoption studies. Several studies have used various techniques to explore the

the probit model. These researchers were more interested in identifying the determinants of adoption of the innovations.

These models (logit, probit and tobit) are more appropriate than ordinary least squares for analysing the decision to use a new technology (Feder et al., 1985). This is because of the underlying specifications of these maximum likelihood models; they have a more discrete range of values. The dependent variable is constrained to values between zero and one in the case of the logit and probit models; and for the tobit model, the dependent variable can be defined to have a lower bound of zero but may take any positive value (Kennedy, 1998).

Adhikary (1994) again employed the rank and scoring approach for understanding the farmers' opinion and perceptions on fodder trees in adoption studies. In analysing the influence of technology characteristics on the rate and speed of adoption of agricultural technology, Batz et al. (1999) also used the scoring approach in Kenya.

As stated earlier, the kinds of models used by these researchers were influenced by their objectives of the studies. In all cases, the tobit was mainly applied for simultaneous determination of factors affecting adoption and/or the incidence and intensity of adoption while the logit and the probit models were used to test only factors affecting adoption or non-adoption.

CHAPTER THREE

METHODOLOGY

3.1. Introduction

This chapter presents the theoretical framework and the analytical tools applied to achieve the research objectives. The data required for the study and the techniques for sampling are also described. This study uses the frequency scoring approach and descriptive statistics to assess the perception and awareness of farmers about the cocoa black pod disease and the recommended control technology. Per hectare cost shares will be computed for the recommended practices under the high level management technological package at the levels of practising farmers to evaluate the cost implications of the technology on the production cost of the cocoa farmer. The Waugh's acceptability index and the logit model will also be used respectively for the estimation of the extent of use of the black pod disease control technology and the determinants of adoption by the farmers.

The technology entails spraying to coat the pods with a solution of either kocide 101, caocobre sandoz, nordox 75, champion or ridomil 72+, which are all fungicides (CRIG, 1995). Only pods are targeted with the chemical, thus trees without pods are not sprayed. Spraying is done using pneumatic spraying machines (hand sprayers), which are mounted at the back after loading with the mixed chemical.

The fact that some of the farmers did not adopt some of the practices made the cost shares computations a bit difficult. Computations were, therefore, done at the level of the farmers who adopted a minimum of 10 out of the 11 recommended practices.

3.2. Theoretical Framework and Analytical Tools

3.2.1. Farmers' Awareness and Perceptions

The first objective of this study is to determine the awareness and perceptions of the cocoa farmers about the black pod disease and the recommended method of control. This will help to modify the control methods in order for adoption of the technology to increase, which will lead to increased land productivity of cocoa farms in the region.

The decision to adopt an innovation begins with farmers being aware of the attributes of the innovation. Farmers' perception may be determined by their experiences of growing the new variety (practising the innovation), extension visits, their knowledge about the innovation and other conditions (Negatu and Parikh, 1999). To determine the level of awareness of farmers about the black pod disease control technology, farmers' knowledge on some important recommendations about the technology were solicited. These recommendations included when to start applying the technology, the spraying interval, appropriate chemicals to use, the right dosage at each spraying and the right type of machine to use in applying the technology. Farmers' levels of awareness were assessed by the proportion of farmers who gave the right responses.

On their perceptions about the technology (the recommended control method), questionnaires were used to obtain information on the applicability, compatibility, relative advantage, effectiveness and the riskiness of the technology, which are considered to be important variables to influence adoption of an innovation. Frequency rankings according to their mention were used to analyse the characteristics of the technology as perceived by the farmers. All responses ranged from one to five for each characteristic.

3.2.2. Evaluation of Farmers' Perceptions

Honlonkou et al. (1999) evaluated the farmers' perceptions about mucuna fallow technology in Benin using ten criteria on a 5-point scale rating beginning from zero. A rating greater than or equal to 3 was considered a satisfactory score and indicated a positive appreciation of the criteria. Similarly for this study, a 5-point rating scale will be adopted with a modification to evaluate farmers' perception. Farmers were asked to assess the characteristics of the disease and the recommended control technology on a 5-point scale as follows: 1 = completely disagree; 2 = disagree; 3 = indifferent; 4 = agree; 5 = completely agree. The characteristics of the disease considered include prevalence in the area, danger posed to farms and its effects on incomes (profits). For the technology, the characteristics considered important and on which cocoa farmers' perceptions were assessed were effectiveness in controlling the disease, tediousness in applying the technology, time involved in applying, initial cost of applying, ease of understanding the technology, possibility of trying the technology, demonstrability of results, observability of results and profitability of applying the technology. The general perception of farmers about the disease and control technology will then be assessed on the basis of the relative frequency of responses.

3.2.3. Cost Share Computations

3.2.3.1. Share of Technology Cost in Total Cost of Cocoa Production

Determination of the proportion of cost contributed by the black pod disease control technology to the total cost of cocoa production by the farmer forms the second objective of this study. The underlying economic theory on factors that are thought to influence the decision to adopt a technology is based on the understanding that farmers are rational and base adoption decisions on their assessment of the potential costs and benefits of the candidate technology (Kalyebara, 1999). This, they usually do through their own research either by experimenting with the technology or analysing secondary information from other key informants in the community.

To estimate the cost contributed by the recommended control technology in the total cost of production, operational costs incurred by the farmers for each of 11 important practices recommended under the high level management technology of which the black pod disease control technology is one were estimated. The practices include weeding, mistletoe control, pruning, capsid control, black pod disease control, fertiliser application, pods harvesting, pods gathering, pods breaking and fermentation, carting of fermented beans and finally, transporting of produce to the selling depots. The recommendations require the cocoa farmers to weed four times every year for effective control of competition for soil nutrients, spray four times against capsids to control insect damage, do a minimum of four fungicidal sprayings to protect pods from rotting and organise a fortnight pods harvesting, gathering and breaking annually to prevent over-ripening and over-fermentation of the pods. Due to soil nutrient depletion after long period of land use, farmers are to apply fertilizers to their cocoa farms and to regularly prune the farms to remove excess shoots and branches to allow for free air circulation and adequate light penetration. Periodic cutting of mistletoes prevents the spread of the parasite, which can cause the death of a whole farm. These form the important areas where the farmers incur annual operational costs in cocoa production.

Data was collected from field interviews on the number of times the practice is used in a year, the number of days used to perform the practice once, the number of labourers employed for each activity under the practice and the unit labour costs per activity. Inputs and materials used for each activity and their prices were also collected for each practice.

3.2.3.2. Estimation Procedure

Cost shares of the 11 recommended practices were estimated at the farmer levels by grouping farmers according to the practices they performed. Ten (10) of the farmers (group 1) performed all the 11 practices while 254 farmers (group 2) performed 10 of the recommended practices. The remaining farmers performed 7 or less number of practices (did not adopt more than 7 out of the 11 practices) and so were excluded in the cost computations.

(i) The cost per hectare $(AC)_{ji}$ for each farmer in a group was computed from the estimated total cost of the practice where $(AC)_{ji}$ is given by the ratio of the total estimated costs for the farmer to the total area used for the practice.

(ii) Summing up the estimated cost per hectare for all the farmers in a group for each practice, the total annual cost per hectare $(AC_{ji})_t$ was derived.

That is $(AC_{ji})_t = \sum(AC)_{ji}$ (3.1)

From (i) and (ii), the cost share (X_{ji}) at the level of each farmer was estimated for each practice where:

$$X_{ji} = (AC)_{ji}/(AC_{ji})_t * 100 \quad (3.2)$$

j = 1…10 for the first group of farmers and 1….154 for the second group of farmers and refers to the participating farmers.

i = 1…11 for the first group and 1…10 for the second group and represents the different practices such as weeding, pruning, black pod control, etc.

With the estimated cost shares on farmer basis for each practice from equation (3.2), the distributional aspects in terms of the minimum, maximum, mean and standard deviation of each practice will be described and the proportional cost contributions of the practices compared. Activities performed by the cocoa farmer himself will be considered as hired labour service and valued at the same rate as the daily wage rate paid in the study area.

3.2.4. Extent of Use of the Black Pod Disease Control Technology

The third objective of this study is to determine the extent of use of the recommended black pod disease control technology by cocoa farmers in the Ashanti Region. The purpose here is to find the extent to which a farmer, after having adopted the technology, is utilising it. The level of utilisation refers to the area committed to the application of the technology by the farmer out of his total cocoa area, while adoption is a measure of four or more sprayings in a year for a minimum of two continuous years.

In a similar analysis, Alao (1973) determined the level of adoption in terms of the percentage of farmers applying the technology, out of the total sampled farmers. This simulates what the logistic or cumulative normal curve does, in describing cumulative adoption over time but on a yearly basis, with the Y-axis defined as the proportion of farmers using the innovation as indicated by Edwin (1996). However, the method becomes similar to the acceptability index proposed by Waugh (1982), and cited in Engmann (1993) when Y is defined as the proportion of the area under the new practice, which then gives an estimate of use intensity. The index is computed as the percentage of representative farmers using the innovation multiplied by the percentage of land area being used for the technology. Engmann (1993), using this index in determining the extent of adoption of soybean in Ghana, had 32% and concluded that the degree of acceptability was very low. The computation is represented as follows;

$$\text{Acceptability Index} = N_s/N_t \times L_s/L_t \times 100 \qquad (3.3)$$

where N_s is the number of farmers in the sample that are using the technology, N_t is the total number of sampled farmers, L_s is the total land area used for the practice out of the total cultivated land area L_t of the total sampled farmers.

This study will also employ the Waugh's acceptability index to analyse the extent of use of the cocoa black pod disease control technology among farmers because of its simplicity. Questionnaires were used to collect information on the cocoa areas being used for the practice by the cocoa farmers who were identified as adopters of the technology. Using equation (3.3), an index was computed, which was used to assess the extent of use of the technology based on its magnitude. The higher the index, the higher the extent of use of the technology and as was defined by Pisanelli et al (2001), an index below 50% was considered low and consequently, interpreted as low acceptability of the technology.

3.2.5. Determinants of Adoption of the Technology

3.2.5.1. Theoretical Background

The fourth objective of this study is to determine the factors that influence the adoption of the black pod disease control technology by cocoa farmers in the Ashanti region of Ghana. This study employed a logit model (Amemiya, 1981) to determine the factors that influence adoption of the black pod disease control technology. The study used the threshold decision-making theory proposed by Hill and Kau (1973) and Pindyck and Rubinfeld (1998). The theory suggests that faced with a decision to adopt or not to adopt an innovation, every farmer has a reaction threshold, which is dependent on certain influential factors. Thus, at a certain value of stimulus below the threshold, no adoption is observed while at the critical threshold value, a reaction is stimulated. Generally, such types of phenomena are modelled using the relationship:

$$Y_i = \psi_I X_i + u_i \tag{3.4}$$

Where Y_i is equal to 1 when a choice is made and zero otherwise. This means

$Y_i = 1$ if X is greater than or equal to a critical value X^* and

$Y_i = 0$ if X_i is less than a critical value X^*.

X^* represents the combined effects of the explanatory variables ($\psi_i X_i$) at the threshold level.

The model is a binary choice model involving estimation of the probability of adoption of a given practice (Y) as a function of explanatory variables (X):

That is $\text{Prob}(Y=1) = F(\beta' X)$ (3.5)

$$\text{Prob}(Y=0) = 1 - F(\beta' X) \tag{3.6}$$

where Y_i is the observed response for the i^{th} observation of the response variable Y. $Y_i = 1$ for an adopter and $Y_i = 0$ for a non-adopter, and X_i is a set of explanatory variables such as age, sex, off-farm income, farm size, etc. associated with the i^{th} individual, which determine the probability of adoption (P) of a given technology. The function F may take the form of a normal, logistic or other probability function. The logit model uses a logistic cumulative distributive function to estimate P as follows (Green, 1993; Pindyck and Rubinfeld, 1998):

$$P(Y=1) = \frac{e^{\beta' X}}{1+e^{\beta' X}} \tag{3.7}$$

$$P(Y=0) = 1 \quad \frac{e^{\beta' X}}{1+e^{\beta' X}} = \frac{1}{1+e^{\beta' X}} \tag{3.8}$$

The probability model is a regression of the conditional expectation of Y on X giving:

$$E(Y/X) = 1[F(\beta' X)] + 0[1 - F(\beta' X)] = F(\beta' X) \text{ (Green, 1993)} \tag{3.9}$$

Since the model is non-linear, the parameters are not necessarily the marginal effects of the various explanatory variables. The relative effect of each explanatory variable on the probability of adoption is obtained by differentiating equation (3.9) with respect to X_{ij} resulting in equation (3.10) below (Green, 1993).

$$\frac{\partial P_i}{\partial X_{ji}} = \left[\frac{\lambda^{\beta' X}}{\left(1+\lambda^{\beta' X}\right)^2}\right]\beta = F(\beta' X)[1-F(\beta' X)]\beta \qquad (3.10)$$

The maximum likelihood method was used for estimating the parameters. Each observation is treated as a single draw from a Bernouli distribution (Green, 1993). Assuming independence of the Y_i's, L is the joint likelihood function for a sample of n observations as in equation (3.11) below.

$$L = \prod_{i=1}^{n} P_i^{y_i}(1-P_i)^{1-y_i} = \prod_{i=1}^{n} F(\beta' X_i)^{y_i}\langle 1-(F(\beta' X_i))\rangle^{1-y_i} \qquad (3.11)$$

Transforming (3.10) to logarithm form gives;

$$\text{In } L = \sum_{i=1}^{n} y_i InF(\beta' X_i) + \sum_{i=1}^{n}(1-y_i)In\langle 1-F(\beta' X_i)\rangle \qquad (3.12)$$

Taking the derivative of InL with respect to β gives the first order condition;

$$\frac{\delta InL}{\delta\beta} = \sum_{i=1}^{n} \langle \frac{y_i f_i}{F_i} + (1-y_i)\frac{-f_i}{1-F_i}\rangle X_i = 0 \qquad (3.13)$$

where f_i is the probability density function and F_i is the cumulative density function of y respectively. The solution of equation (3.13) gives $\hat{\beta}$, which is the maximum likelihood estimator (Pindyck and Rubinfeld, 1998).

In applying the model in this study, the implication is that the cocoa farmer would adopt the recommended black pod control technology at a point when the combined effects of the socio-economic, technical and institutional factors exceed and overcome the inherent resistance to change in the farmer. In adoption studies, the use of probability models is conceptually preferable to conventional linear regression models because parameter estimates from the former are asymptotically consistent and efficient; the estimation procedure also resolves the problem of heteroscedasticity and constrains the conditional probability of making a choice to lie between zero and one. The logit model is preferred to the probit model because of its mathematical convenience (Green, 1993; Kalyebara, 1999).

3.2.5.2. Empirical Model Specification

In this study, farmers who sprayed their farms against the black pod disease for at least four times a year for a minimum of two continuous years were considered adopters of the technology. Less than four sprayings a year has been found not to achieve results and so could not pass for adoption, while farmers who practised the technology for only a year were said to be trying the technology and could not pass for adoption.

According to Feder et al. (1985), farmers' adoption behaviour in low-income countries is influenced by a complex set of socio-economic, technical and institutional factors. Some relevant variables were therefore hypothesised in accordance with the objective of the study and direction from literature, to influence the adoption of the cocoa black pod disease control technology in the Ashanti Region. These included socio-economic characteristics of the farmer, institutional factors that determine the farmers' ability to acquire inputs used for the technology application and technology specific factors that influence the demand for and use of the black pod control technology by the farmer.

The index level X_t can be specified as:

$$X_t = \beta_0 + \beta_1 X_1 + \ldots\ldots + \beta_N X_N + \varepsilon_i \qquad (3.14)$$

where:

β_0 = constant

ε_i = Error term, N,I,D $(0,\sigma^2)$

A logit model was estimated for the adoption of the recommended method of control for the cocoa black pod disease. The model assumes that there exists a theoretical continuous index Z that is determined by a vector of explanatory variables X (CIMMYT, 1993). Thus, following Gujarati (1988), the logit model was specified as:

$$Z_i = \ln\left(\frac{P}{1-P}\right) = \beta X_t + \varepsilon_i \qquad (3.15)$$

where X_t is reflecting the combined effects of X independent variables that prevent or promote adoption.

$X_1 \ldots X_N$ are the factors that limit or promote adoption, and are defined as follows:

X_1 = Age group (youth or old) of farmer in years (dummy variable)

X_2 = Gender of farmer (dummy variable)

X_3 = Educational level of farmer (grouped dummy variables)

X_4 = Farmer's working experience in years.

X_5 = Farm size in hectares

X_6 = Annual cocoa income (value of number of bags of 62.5 kilograms weight)

X_7 = Annual off-farm income (dummy)

X_8 = Household labour size (grouped dummy)

X_9 = Membership of an association (dummy variable)

X_{10} = Number of extension contacts received by the cocoa farmer (grouped dummy)

X_{11} = Distance to the nearest inputs source (grouped dummy)

X_{12} = Farmers' perception about price of inputs (dummy variable)

X_{13} = Access to credit by farmer (dummy variable)

3.2.5.3. Choice of explanatory variables for the model

The reasons for choosing the explanatory variables above and their a-priori expectations are as follows:

Farmer's age: A farmer's age either generates or erodes confidence in new technology. In other words, with old age comes experience, all things being equal, and the farmer becomes more or less risk averse when judging new technology. The variable could thus have a positive or negative effect on the farmers' decision to adopt the cocoa black pod control technology. Age in this study, was measured with a dummy, 1 for farmers aged 50 years and above (old farmers) and 0 otherwise (for youthful farmers below the age of 50 years). The grouping was to allow for categorising cocoa farmers into two age groups; the aged and the youth as different age groups, according to FAO (1986), affect farmers' participation in agricultural activities differently. Knepper (2001) used a dummy for the age variable in fertilizer adoption studies in Zambia and hypothesized that the youth whose age ranged between 25 and 49 years will have a higher probability of using fertilizer. In the adoption of the black pod disease control technology, age groups play very important roles, especially when it comes to the farmer doing the spraying himself due to financial and labour constraints that frequently face the cocoa farmers. The grouping also became necessary because the original and ungrouped age data turned out not significant, though the variable is very important for the technology adoption and so could not be removed from the model.

Gender of farmer: With respect to the black pod disease control technology, mounting of the pneumatic (hand sprayer) machines filled with the chemical at the back is most often an exclusive job for the males. Thus a female cocoa farmer without a caretaker and who may be financially constrained is likely to shy away from adopting the technology, while a male farmer is likely to adopt. Conversely, female cocoa farmers with good financial standing and easy access to extension services are highly favoured to adopt the technology since they are considered to be more receptive to extension advice. The variable was therefore expected to influence adoption of the technology in either direction. Gender was represented with a dummy: 1 for a male farmer and 0 for a female farmer.

Educational Status: Higher education should increase the cocoa farmer's ability to obtain, process, and use information relevant to the adoption of the black pod control technology. Higher education was thus hypothesised to increase probability that the cocoa farmer will adopt the cocoa black pod disease control technology. The education variable was categorised into four levels (no education, basic level, secondary level and tertiary level) and each measured independently as a dummy, 1 representing a particular level and 0 otherwise.

Farmer's working experience: Farmers' accumulated experience in cocoa production was predicted to positively influence adoption of the technology. Working experience was represented by the number of years the farmer has been in cocoa farming.

Farm size: Farm size is an indicator of wealth. It is expected that well maintained large cocoa farms will provide enough revenue to cover all the technology adoption costs. It was therefore expected to be positively associated with the decision to adopt the cocoa black pod control technology. Conversely, large farms may require large capital for procuring the inputs needed for the application of the technology and so discourage farmers from adopting, in which case it was expected to be negatively related to the adoption of the technology. Farm size was measured in hectares of matured and bearing cocoa farms.

Annual cocoa income: It is assumed that part of the realised cocoa farm income will be reinvested for further profits as the farm is supposed to be run as a business. Thus, higher cocoa farm incomes will lead to adoption of the technology. The a priori expectation of the effect of farm income on adoption therefore, was positive. The revenue derived from the cocoa farmer's farm produce in bags of 62.5 kilograms weight was used as a proxy for farm income.

Annual off-farm income: Since the acquisition of the inputs needed to apply the technology depends on the availability of funds, cocoa farmers who are privileged to have other sources of income other than cocoa are put in a better stead to adopt the technology. The proportion of the cocoa farmer's non-cocoa income in the total annual income was expected to positively influence the adoption of the cocoa black pod disease control technology. Braun et al. (1994) grouped the variable into dummies and observed that farmers with higher proportions of off-farm income in total income were encouraged to procure inputs required for application of the innovation in Rwanda. Non-cocoa income, which was used as a proxy for off-farm income, was measured as a dummy. 1 represented farmers who had higher proportions of income outside proceeds from cocoa and 0 otherwise.

Household labour size: Availability of household labour is likely to supplement and reduce total labour costs as labour required for spraying, drawing of water and other processes will be provided by them. Thus, availability of household labour was expected to increase the probability of adopting the cocoa black pod disease control technology. The variable was measured with a dummy. Farmers with 2 or more available household labourers were represented with 1 and 0 represented those with less than 2 labourers from the household. This is because the successful application of the technology requires the services of a minimum of 2 labourers for the tasks of machine operator and a water carrier, especially in the case of the old farmers who are not in a position, health wise, to contribute in any form. Since activities performed by the farmer himself were considered as hired labour service and valued at the same rate as the daily wage rate paid in the area in this study, the services of a healthy farmer qualified to be classified as a household labour service. Pannel (2001) indicates in study of practices to prevent dry land salinity in Australia that the availability of the farmer's services impacts positively on technology adoption.

Membership of associations: Being a member of an association was hypothesised to be positively associated with the adoption of the cocoa black pod disease control technology. A dummy measured the variable: 1 for a farmer belonging to any farmers' group/association and 0 otherwise.

Extension contacts: The adoption of the technology is dependent on the extent that knowledge is passed on from the extension frontline staff about the technology to farmers through regular interactions and contacts. It was thus expected that extension contact would have a positive effect on the adoption of the cocoa black pod disease control technology by cocoa farmers. The assumption here was that once the cocoa farmer has had frequent contacts with the source of knowledge about the technology, he/she would be put in a better position to decide positively to adopt the technology. The variable was measured with a group dummy. Farmers who received 12 or more extension contacts were represented with 1 while 0 represented those with less than 12 contacts. A frequency of 12 or more contacts in a year is an indication of at least a monthly visit by the extension agent to the farmer, which will be enough to get the farmer well educated about the technology. Zinnah et al. (1993) indicate in a study of adoption of swamp rice technology in West Africa that consistent monthly visit helps to bring the farmer closer to the reaction threshold thus, increasing the likelihood of the farmer adopting the technology. Mussei et al. (2001) used a dummy for the extension variable and hypothesized that a monthly contact with the extension worker will increase the farmer's likelihood of adopting improved wheat technologies. Croppenstedt and Demeke (1996) also used a dummy for the variable and explained that good and strong extension services, which provide at least a monthly visit to the farmer, will positively correlate with fertilizer adoption. The grouping also became necessary because the ungrouped data turned out not significant in the model.

Distance to inputs source: Input accessibility in terms of distance to the nearest source is an important factor in the application of the black pod disease control technology. Due to the bulkiness of inputs and the additional high transportation costs, farmers may wish to have input sources as close as possible. The variable was hypothesized to relate negatively to adoption of the technology. Distance to input sources were measured with a dummy. 1 represented a distance of less than or equal to 8 kilometres while 0 represented distances more than 8 kilometres. Knepper (2001) used a dummy for the variable in a study of fertilizer use in Zambia to account for differences arising out of location of fertilizer distributors, which situation applies in this study. Apart from the fact that the complaints of the farmers are minimized if travelling distances to input sources are within 0 to 8 kilometres, which is one of the expectations of the Cocoa Inputs Society, the ungrouped distances turned out not significant in the model.

Price of inputs: The price of inputs required for the application of the technology adds to the operational costs, which may increase the cocoa farmers' financial constraints. It is therefore expected that farmers' adoption of the technology will decrease as the prices of inputs are perceived to be high and adoption will increase if the prices are viewed to be low or normal. Thus, market price of the inputs was expected to have a negative effect on the adoption of the black pod control technology if perceived to be high. A dummy was used to measure the variable. 1 represented the view that input prices are high and 0 represented the view that input prices are normal.

Access to credit: Cocoa farmers who have access to credit can ease their financial constraints. This is more so considering the fact that the application of the technology demands the acquisition of fungicides and hand sprayers at the beginning of the season, when cocoa farmers are normally financially constrained. It was therefore hypothesized that access to credit would increase the probability of adoption of the cocoa black pod disease control technology. Access to credit was represented as "1" if the farmer received credit in cash or in kind (inputs) and "0" otherwise.

3.3. Sources of data

Primary data were used for all the analyses. Data were collected through a structured sample survey[2] conducted in four (4) out of the eight (8) cocoa districts in the Ashanti Region. A purposive selection of Mampong, Offinso, Tepa and Nkawie out of the eight districts was done because the incidence of the disease is high in these districts while it is virtually non-existent in Juaso, Antoakrom, Obuasi and Fumso Districts. Using simple random sampling techniques, the survey covered 300 farmers from a total of twenty (20) units[3] selected proportionately from the four (4) cocoa districts (Appendix 2). Since the districts are divided into unequal number of units, a proportional number of units were randomly selected from each of the four districts using the District Officers' lists at the District Extension Office. At the unit level, fifteen (15) farmers were again randomly selected using the farmers' registers kept by the extension agents in-charge of the units.

A sample size of 300 was chosen on grounds of financial and time constraints, given the limited resources available and considering the fact that the researcher was required to travel to four districts, which are widely dispersed. A larger sample size would have demanded the services of more enumerators during the questionnaire administration, which was also not within the means of the researcher. However, a sample size of 300 was deemed large and representative enough for statistical reliability as far as this study is concerned.

2. The structured questionnaire administered in the survey is presented in appendix 1.
3. A division of a cocoa district with a cocoa area of 3,000 acres.

CHAPTER 4

EMPIRICAL RESULTS AND DISCUSSION

4.1. Introduction

This chapter provides a discussion focused on identifying and comparing factors that can be used to explain differences in adoption of the black pod disease control technology. It begins with a discussion of the results of the first three specific objectives of the study, which is then followed by a brief description of the characteristics of the sampled cocoa farmers and the socio-economic and institutional variables employed in the logit model.

4.2. Farmers' Awareness and Perceptions About the Technology

Assessment of cocoa farmers' awareness and perceptions of the attributes of the recommended technology forms the first objective of this study. The awareness of the cocoa farmers about the technology was evaluated on five attributes of the technology, which were measured in terms of the proportion of farmers who expressed knowledge of the attributes.

Knowledge about the best time to start spraying against the disease is considered a good measure of the cocoa farmers' awareness about the technology. Seventy-seven percent of the sampled farmers showed a high degree of awareness of the recommended time to commence applying the technology (Table 4.1). Eighty-seven percent of the sample were aware of the application interval of three weeks, 88% also indicated that they were aware of the recommended dosage of one sachet of chemical to be used per machine fill. Lastly, about 90% of the respondents confirmed their awareness of the recommended type of machine to be used for the application of the technology.

Table 4.1: Cocoa Farmers' Awareness About the Technology Characteristics

Technology characteristics	Aware (%)	Not aware (%)	Total
When to start spraying	77.3	22.7	100
Recommended spraying interval	87.0	13.0	100
Recommended chemicals to use	88.0	12.0	100
Recommended quantity of chemical per machine fill	85.7	14.3	100
Recommended type of machine	89.7	10.3	100

Source: Computation based on author's survey data

On the average, 86% of the sampled farmers showed awareness of all the major characteristics of the technology. These results indicate a high degree of awareness about the control technology in the region. The results corroborate the findings of Dankwa (2000) in a study of factors affecting the adoption levels of cocoa technologies in the Ashanti Region, which concluded that a majority of the farmers in the region were well aware of when, how and why recommended practices should be applied.

Using a one-variable case chi-square test with one degree of freedom at an α-level of 0.05, a comparison was made between the two categories of farmers' responses on their awareness levels (Table 4.2), and the results indicate that the two response categories ("aware" and "not aware") are significantly different.

Table 4.2: Comparison of Awareness Levels on Technology Characteristics

Characteristic	Aware	Not aware	X^2- calculated
When to start spraying	232	68	89.7
Recommended spraying interval	261	39	164.3
Recommended chemicals	264	36	173.3
Recommended dosage of chemical	257	43	152.7
Recommended type of machine	269	31	188.8

Source: Computation based on author's survey data.

The study investigated the perceptions of cocoa farmers about 3 important characteristics of the black pod disease and 8 characteristics of the control technology. On the characteristics of the disease, farmers' perceptions on its prevalence in the area and its effects on their farms and incomes (profits) were evaluated and the results are presented in Table 4.3.

Table 4.3: Cocoa Farmers' Perceptions about the Black Pod Disease

Characteristics of disease	Completely disagree		Disagree		Indifferent		Agree		Completely agree		Totals	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Very prevalent	2	0.7	1	0.3	16	5.3	152	50.7	129	43.0	300	100
Poses danger	0	0	0	0	3	1.0	107	35.7	190	63.3	300	100
Reduces farm income/profits	1	0.3	0	0	2	0.7	75	25.0	222	74.0	300	100

Source: Computation based on author's survey data

The results indicate that only 3 (1%) of the respondents perceived the disease as not prevalent in the area and so warrants no serious attention, while a large majority (94%) perceived it to be very prevalent. However, 5% were indifferent about the prevalence of the disease in the area. On the danger that the disease poses to the cocoa farmers' farms, almost all the sampled farmers (99%) held the perception that their farms were at high risk of being devastated by the disease if no serious control measures were taken, while one percent remained indifferent. Similarly, 99% of the farmers perceived the disease as having negative impacts on their incomes and profits while about 1% remained indifferent.

The results demonstrate that cocoa farmers in the region generally perceive the black pod disease to be very prevalent in the region and so poses great danger to their farms, as well as serve as a major source of loss in incomes. This reflects what really pertains in the region, especially in districts such as Offinso/Akomadan, Tepa, Nkawie/Nyinahin and Mampong where the *Phytophthora megakarya* strain is the major causal agent of the disease.

Presented in Table 4.4 is a further comparison of farmers' perception levels about the black pod disease using the one variable case chi-square test with two degrees of freedom. The different responses of the farmers are statistically different at an alpha level of 0.05. Thus response categories, 'agree', 'indifferent' and 'disagree' are significantly different and in effect, are differently preferred by the farmers.

Table 4.4: Comparison of Cocoa Farmers' Response Levels About the Disease

Characteristics of Disease	Agree	Indifferent	Disagree	X^2-Calculated
Prevalence	281	16	3	510.1
Poses danger	297	3	0	582.2
Reduces farm income	297	2	1	582.1

Source: Computation based on author's survey data.

Farmer perceptions were evaluated on the technology's relative advantage, compatibility, complexity, trialability and observability. Relative advantage was assessed with a number of indicators including profitability, initial cost, savings in time and effort, and effectiveness. Complexity is also captured as the ease of understanding the technology. Demonstrability of the results of applying the technology and the ease of trying the technology were the indicators to assess trialability. The results are presented in Table 4.5.

Generally, cocoa farmers in the region perceived the relative advantage of using the technology to be low. Apart from its effectiveness in controlling the disease and high potential for reward in terms of profits, the respondents perceived all the dimensions of the relative advantage unfavourable. Thus, 93% of the 300 respondents perceived the technology to be very effective in controlling the disease, while 83% believed that the technology is profitable when used. On the other hand, farmers perceived the technology to be very expensive to use (74%), tedious (78%), and demanding on time (83%).

Table 4.5: Cocoa Farmers' Perceptions About the Control Technology

Characteristics of technology	Completely disagree		Disagree		Indifferent		Agree		Completely agree		Totals	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Very effective	3	1.0	0	0	18	6.0	151	50.3	128	42.7	300	100
Not tedious in applying	179	59.7	57	19.0	22	7.3	26	8.7	16	5.3	300	100
Not time involving in applying	107	35.7	141	47.0	19	6.3	19	6.3	14	4.7	300	100
Low initial cost	97	32.3	126	42.0	27	9.0	45	15.0	5	1.7	300	100
Easy to understand	11	3.7	2	0.7	34	11.3	195	65.0	58	19.3	300	100
Can be tried easily	5	1.7	10	3.3	15	5.0	185	61.7	85	28.3	300	100
Results are easily demonstrable	3	1.0	5	1.7	25	8.3	152	50.7	115	38.3	300	100
Results are easily observable	3	1.0	0	0	16	5.3	114	38.0	167	55.7	300	100
Profitable to apply	14	4.7	18	6.0	19	6.3	66	22.0	183	61.0	300	100

Source: Computation based on author's survey data.

These perceptions about the attributes of the technology form the basis of the unwillingness of the farmers in the region to adopt the technology after trying it on a limited basis.

A summary of the results on the technology's relative advantage presented in Table 4.6, further indicates that farmers in the region generally perceive the technology to be trialable, not complex with demonstrable and observable results. Eighty-four percent of the respondents indicated that it is very easy to understand and use it. Similarly, 90% indicated that the technology can be tried on a limited basis for observation. On the demonstrability aspect, 89% stated that the results are easily demonstrable when the technology is applied anywhere. Ninety-four percent perceived results after applying the technology to be observable at any time and at any place.

Thus, cocoa farmers in the region generally have good perceptions about the black pod disease control technology, but also recognize the cost of application, tediousness and time demanding aspects of it. Considering that perceptions of technology characteristics are critical in driving farmers' adoption behaviour (Adesina et al., 1997), negative perceptions about costs, tediousness and demands on time are likely to limit adoption of the technology.

Table 4.6: Summary of Cocoa Farmers' Perception About Technology's Relative Advantage

Characteristics	Agree (%)	Disagree (%)	Indifferent (%)
Effective in controlling disease	93.0	1.0	6.0
Very profitable if applied	83.0	10.0	6.3
Low initial cost to apply	16.7	74.3	9.0
Not tedious in applying	14.0	78.7	7.3
Not time involving	11.0	82.7	6.3

Source: Computation based on author's survey data.

A comparison is made between the different response categories (Table 4.7) to verify the significance of the difference in responses using the one-variable case chi-square test. Each response category according to the test is exclusively preferred as they are significantly different at the 0.05 alpha level. Thus the responses are statistically different indicating that the response categories are differently preferred.

Table 4.7: Comparison of Cocoa Farmers' Response Levels on Technology Characteristics

Characteristics of Technology	Agree (%)	Indifferent (%)	Disagree (%)	X^2-calculated
Effectiveness	279	18	3	375.3
Not tedious in applying	42	22	214	397.8
Not time demanding in applying	33	19	248	674.2
Low initial cost	50	27	223	167.7
Easy to understand	253	34	13	411.2
Can be tried	270	15	15	396.7
Results easily demonstrable	267	25	8	316.5
Results easily observable	281	16	3	385.9
Profitable to apply	249	19	32	345.4

Source: Computation based on author's survey data.

4.3. Share of Technology Cost in Total Cost of Cocoa Production

This section presents statistics on the farmers' performance levels of the 11 recommended practices qualitatively (using frequencies, means and modes) and estimates of the shares of the cost of the practices in the total cost incurred by the farmers in cocoa production. The estimated costs for the practices (including black pod control) recommended under the high level management technology for cocoa production were used to allocate the cost shares (Appendix 3) for full adopters of the 11 recommended practices and adopters of 10 of the practices, respectively. A total of 10 farmers were involved in the adoption of all the 11 practices, while 154 of the respondents practised 10 of the recommendations. These statistics indicate that not all the 300 sampled farmers performed all the recommended practices to the full. Though these do not conform to research recommendations, the farmers had various reasons for doing that, which are explained in section 4.4.

4.4. Descriptive Statistics on Cocoa Farmers' Performance of the Recommended Practices

Although all the 300 sampled farmers weeded their farms every year, most of them achieved lower frequencies instead of the 4 times recommended (Table 4.8). About 4% of the respondents did only one weeding the whole year round with majority of them (69%) doing two weedings while 26% weeded thrice a year. Only 2% followed the recommendations and weeded four times in a year. The mean number of weeding per year is 2 and the mode is 2. Their explanations are that most of the farms are old, have closed canopies and so weed regeneration is adequately checked.

Table 4.8: Frequency of Weeding Farms Annually by Cocoa Farmers

Number of times weeded	Frequency	Valid %	Cumulative %
1	11	3.7	3.7
2	206	68.7	72.3
3	78	26.0	98.3
4	5	1.7	100.0
Total	300	100.0	

Source: Computed from author's survey data.

Two hundred and ninety-one (97%) of the respondents indicated that they control mistletoes annually. Mistletoe, which is a parasite, is a problem in cocoa production especially, in the old farms. Cutting of mistletoes is recommended to be done and completed once in a year. Those who did not perform the recommendation explained that the problem does not exist on their farms.

Pruning involves the removal of excess shoots and branches as well as dense overhead shade to make the farms airy and allow for adequate light penetration for optimum production. This practice is normally recommended to be undertaken once a year at the beginning of the season when the cocoa trees have developed excess branches and leaves. Two hundred and fifty-four (85%) of the respondents practised the recommendation. The remaining indicated that their farms were already old and even had broken canopies, which did not require any pruning to remove excess shoots and branches.

Sixty-five percent of the sampled farmers controlled the black pod disease to some extent on their farms annually. Research recommendations demand a 3 - weekly interval sprayings starting from April/May after the appearance of chereles on the trees. This results in a minimum of 4 and a maximum of 7-9 sprayings in a year. Sixty-three percent of the respondents in this study met at least the minimum of 4 sprayings a year recommended, which qualified them to be classified as adopters (Table 4.9). Thus, there were a total of 122 adopters out of the 300 sampled farmers. Twenty-three percent sprayed 4 times a year with 20% spraying 5 times; and 14% and 5% sprayed 6 and 7 times in a year respectively. On average, farmers spray between 2 and 3 times every year and the mode is 4. The explanation for their inability to achieve the recommended frequency of spraying centred on high cost of inputs and labour constraints.

Table 4.9: Frequency of Spraying Against the Black Pod Disease Annually by Cocoa Farmers

Number of times sprayed	Frequency	Valid %	Cumulative %
Less than 4	73	37.3	37.3
4	45	23.1	60.4
5	39	20.1	80.5
6	28	14.4	94.9
7	10	5.1	100.0
Total	195	100.0	

Source: Computation based on author's survey data.

Eighty-nine percent of the 300 farmers interviewed controlled capsid damage on their farms annually. Though research recommends a maximum of 4 sprayings a year, most of the sampled farmers (44%) who practiced the recommendation did only 2 sprayings annually (Table 4.10). Thirty percent of the practitioners sprayed 3 times while 15% sprayed 4 times a year. On average, farmers spray betwe4en 2 and 3 times with a few of them spraying 3 times a year. The mode is 2. Their complaints about the high cost of chemicals and machines explain this scenario.

Table 4.10: Frequency of Spraying Against Capsids Annually by Cocoa Farmers

Number of times sprayed	Frequency	Valid %	Cumulative %
1	29	10.9	10.9
2	118	44.2	55.1
3	81	30.3	85.4
4	39	14.6	100.0
Total	267	100.0	

Source: Computation based on author's survey data

Only 3% of the sampled farmers applied fertilizers on their farms annually. Fertilizer application is recommended to be undertaken once a year, especially in the old cocoa farms to help replenish the soil of lost nutrients. The general complaint was that the prices of the fertilizers were too high to enable them do the procurement in the absence of any form of credit facilities.

All the 300 respondents undertook pods harvesting, gathering and heaping, breaking and fermentation, carting of fermented beans and transporting of produce to the selling depots. Research recommends a 2-weekly harvesting of pods, which will lead to a minimum of about 5 to 7 harvestings annually to prevent over-ripening of pods. Most of the farmers in this study (82%) undertook 3-4 harvestings annually (Table 4.11). Only about 11% harvested pods more than 5 times a year. The mean frequency of pods harvesting, breaking, carting and transporting is 4 and the mode is 4. The farmers complained that the recommended frequency of two-weekly harvesting is time and labour demanding, and will tend to increase their operational costs.

Table 4.11: Frequency of Annual Pods Harvesting, Gathering, Breaking, Beans Carting and Transportation

Number of times	Frequency	Valid %	Cumulative %
Less than 3	20	6.3	6.7
3 – 4	246	82.0	88.7
5 – 7	34	11.3	100.0
Total	300	100.0	

Source: Computation based on author's survey data.

4.5. Results of Cost Shares Estimation

The results of the survey indicate that the black pod disease control technology recommendation is generally expensive and contributes the highest share to the total cost of production of cocoa beans. The statistics indicate that the maximum cost incurred by the farmers was contributed by the black pod control technology (50%) followed by the fertilizer application recommendation (39%) with weed control and pods harvesting contributing about 21% and 20% maximum cost shares, respectively, under the adoption of the full complement of the recommended practices (Table 4.12).

Table 4.12: Cost Shares of Recommended Practices for Cocoa Production (Full Complement of Practices)

INDOICATORS	PRACTICES										
	Weeding	Mistletoe Control	Pruning	Capsid Control	Black pod Control	Fertilizer Application	Pods Harvesting	Pods Gathering	Pods Breaking	Beans Carting	Transporting of produce
Minimum (%)	2.46	0.47	0.21	2.40	23.34	20.99	1.48	1.95	0.98	0.98	0.02
Maximum (%)	20.87	4.83	2.42	17.63	50.05	39.02	20.03	18.41	9.00	9.00	1.78
Mean (%)	6.48	2.16	1.04	8.35	36.37	28.70	5.23	4.90	3.35	2.62	0.83
Standard Deviation	5.63	1.47	0.85	5.03	9.61	6.52	5.30	4.81	2.95	2.72	0.60

Source: Culled from Appendix 5a.

The highest among the minimum cost shares is 23% and was contributed by the black pod disease control technology, followed by the fertilizer application (21%). On the average, the black pod disease control technology contributed a cost share of 36%, which is the highest among the mean cost shares and is closely followed by the fertilizer application (29%) with capsid and weed control contributing mean cost shares of 8% and

6%, respectively. The standard deviation is also highest for the black pod disease control technology (about 10%) and fertilizer application (about 7%), which means the cost shares of the technologies are widely dispersed around their mean cost shares. These go to reinforce the notion that the two technologies (black pod disease control and fertilizer application) are relatively expensive.

Covering a wider spectrum of farmers (154) who adopted all the recommendations with the exception of fertilizer application, a further comparison is made on the cost shares contributed by the practices at the farmer level (Table 4.13).

Table 4.13: Cost Shares of Recommended Practices for Cocoa Production (10 Practices Excluding Fertilizer Application)

INDICATORS	PRACTICES									
	Weeding	Mistletoe Control	Pruning	Black pod Control l	Capsid Control	Pods Harvesting	Pods Gathering	Pods Breaking	Carting of beans	Transporting of Produce
Minimum (%)	1.50	0.48	0.09	6.98	0.84	1.18	0.28	0.56	0.42	0.04
Maximum (%)	50.32	28.85	14.96	71.83	35.30	37.47	32.04	23.13	20.60	8.37
Mean (%)	13.22	4.94	2.05	36.80	13.13	9.37	7.98	6.26	4.79	1.46
Standard Deviation	10.30	4.27	2.21	13.92	7.41	5.86	4.94	4.61	3.70	1.44

Source: Culled from Appendix 5b.

Again, the highest among the minimum cost contributions was made by the black pod disease control technology (7%) with weed control and pods harvesting contributing a little over 1% each. All the practices contributed minimums of less than 1% each. A maximum cost share of about 72% was contributed by the black pod disease control technology as against 50%, 37%, 35%, 32%, 29%, 23%, 20% and 15% contributed by weed control, pods harvesting, capsid control, pods gathering, mistletoe control, pods breaking and pruning recommendations in that order. The highest mean cost share of all the practices (37%) was contributed by the black pod disease control technology with the closest being 13% and contributed by the weed and capsid control practices. Finally, the results show that the distribution of cost shares is more widely dispersed around the mean cost share for the black pod disease control technology (standard deviation of 14%) compared to the other practices such as weed control (10%), capsid control (7%), pods harvesting (6%) and pods gathering and breaking (5% each).

The statistics in Table 4.13 confirm the costly nature of the black pod disease control technology as perceived by the farmers. An average cost contribution of about 36% by the black pod disease control technology alone, to the total cost incurred by the farmer for all the 11 recommended practices makes the use of the technology appear cost intensive. This is likely to scare the farmers from adopting the technology as compared to the old and traditional cultural method of removing infected pods, which involved no cash investments, but which could control only the palmivora pod rot and not the more virulent megakarya pod rot.

This therefore forms the basis of the cocoa farmers' general cry in the region for a less expensive but effective technology. The results also compare favourably with the findings of the scientific research conducted at the Cocoa Research Institute of Ghana, which came out with an estimated proportional cost contribution of 32% for the black pod disease control technology and which forms the basis of the cost components in the estimation of the producer price of cocoa annually (COCOBOD, 2003).

4.6. Extent of Use of the Black Pod Disease Control Technology

This section presents the results of the objective of determining the extent of use of the cocoa black pod disease control technology in the Ashanti Region using an index of adoption adapted from Waugh (1982) in Engmann (1993), and Hildebrand and Poey (1985) in Pisanelli et al. (2002). The extent of use in this study is defined as the proportion of representative farmers using the technology multiplied by the proportion of land area being used for the technology, and is a measure of acceptability of the technology. The extent of use among adopters was also estimated as the ratio of the cocoa area on which the technology is applied by adopters to their total area of cocoa. Details of the computations are as follows:

4.7. The Acceptability Index

The acceptability index measures the extent to which the technology is adopted and applied on the cocoa farms belonging to the 300 sampled farmers.

Given that:

(i) Total number of sampled cocoa farmers = 300

(ii) Total number of cocoa farmers in the sample using the technology (adopters) = 122

(iii) The proportion of cocoa farmers in the sample using the technology = **0.4067**

Also,

(iv) Total cultivated cocoa area for the 300 sampled farmers (hectares) = 1934.3

(v) Total cultivated cocoa area (hectares) on which the technology is applied (adopters) = 749.5

(vi) Thus proportion of cocoa area being used for the technology = **0.3875**

Hence Acceptability Index of the technology = 0.4067 x 0.3875 x 100

= **15.76%**

The estimated 16% value of index suggests that the degree of acceptability of the technology in the region is very low, which implies a low extent of use of the technology in the Ashanti Region. Pisanella et al. (2002) had an index of 26% and concluded that the extent of use of improved tree fallows technology in Western Kenya was too low using a rate of 50% as the minimum acceptable level.

4.8. Extent of Use of the Black Pod Disease Control Technology Among Adopters

The estimated extent of use among adopters measures the proportion of cocoa area on which the 122 adopters apply the technology.

Given that:

Total cultivated area of adopters (hectares) = 1005.1

Total area on which technology is applied (hectares) = 749.5

The extent of use among adopters $= \frac{749.5}{1005.1}$

= **0.746**

The results of the estimates indicate that about 75% of the cocoa area of the adopters is used for the technology application, which is high and encouraging. However, there is the need for improvement as the value of pods that will be lost from the remaining unused

25% area could be substantial aside the possibility of inoculum build up, which will be a source for the re-infection of the sprayed and protected pods.

4.9. Determinants of Adoption of the Black Pod Disease Control Technology

4.9.1. Socio-economic Characteristics of Cocoa Farmers

The socio-economic characteristics considered in this study include age, gender, educational level, experience in cocoa farming, farm size, annual income from cocoa, household labour availability, and membership of associations or organisations. The results reveal that a majority of respondents (81%) fell into the category of aged farmers who are 50 years and above, with only 19% lying between the ages of 23 to 49 years (Table 4.14). The mean age of the farmers is 59.8 years while the mode is 60-69 years.

Table 4.14: Age Distribution of Cocoa Farmers

Age (years)	Frequency	Valid %	Cumulative %
20 – 29	2	0.7	0.7
30 – 39	10	3.3	4.0
40 – 49	44	14.7	18.7
50 – 59	81	27.0	45.7
60 – 69	90	30.0	75.7
70 – 79	65	21.6	97.3
80 and above	8	2.7	100.0

Source: Computed from author's survey data.

This scenario does not augur well for adoption of technologies, especially labour intensive technologies such as the black pod disease control technology. Younger farmers have been reported as having greater likelihood of adopting new technologies due to their longer planning horizon and zeal to acquire and use farm information as compared to older farmers (Onu, 1991).

This situation is even complicated by the fact that the more energetic youth who will supply the labour requirements are migrating to the urban centres, thus creating labour scarcity for these old cocoa farmers.

The 300 sampled farmers were predominantly males (75%). About 47% of all sampled farmers were illiterates with no formal education while 43% attended school up to the basic level with only 6% and 4% reaching secondary and tertiary levels, respectively (Table 4.15). According to Getahun et al. (2000), exposure to education enhances the receptiveness of an individual to extension education and increases the farmer's ability to obtain, process and use information relevant to adoption. The educational level of the sample, therefore, portrays an unhealthy indicator for adoption of the black pod disease control technology.

Table 4.15: Distribution of Cocoa Farmers' Formal Educational Levels

Formal Educational Level	Frequency	Valid%	Cumulative %
None	140	46.7	46.7
Basic	130	43.3	90.0
Secondary	18	6.0	96.0
Tertiary	12	4.0	100.0
Total	300	100.0	

Source: Computed from author's survey data.

Working experience of the sampled cocoa farmers (Table 4.16) ranges from 2 to 60 years with a mean of 29 and a mode of 11-20 years. Only 9% of the farmers have less than 11 years working experience in cocoa farming. The rest have been cocoa farmers for 11 years and above. Sixteen percent have worked as cocoa farmers for more than 40 years while 47% have been in the cocoa business for a period between 20 and 40 years. This indicates that most of the farmers have been in the cocoa farming business for quite sometime. Experience, which comes from a store of knowledge after long period of practice, helps to increase technology adoption. Thus, the results are favourable signs to encourage increased adoption by the farmers.

Table 4.16: Distribution of Farming Experience of Cocoa Farmers

Experience in Years	Frequency	Valid %	Cumulative %
Less than 11	28	9.3	9.3
11 – 20	83	83.0	37.0
21 – 30	73	24.3	61.3
31 – 40	68	22.7	84.0
More than 40	48	16.0	100.0
Total	300	100.0	

Source: Computed from author's survey data.

The sizes of cocoa farms of the sampled farmers range from a minimum of 0.2 hectares to a maximum of 39.2 hectares (Table 4.17). The mean farm size is 6.4 hectares and the mode is 2.0 hectares. Sixty percent of the farms are less than 6.4 hectares in size while 38% are greater than the mean farm size, which forms 2% of the total number of farms.

Table 4.17: Distribution of Farm Sizes of Cocoa Farmers

Farm Size (Ha)	Frequency	Valid %	Cumulative %
Less than 6.4	180	60	71.3
6.4	6	2	62.3
More than 6.4	114	38	100

Source: Computed from author's survey data.

The above distribution of farm sizes shows that most of the farms are small. This is expected to positively encourage adoption of the black pod disease control technology as inputs required for the application of the technology on a farm will be reduced. Due to financial constraints at the beginning of the season when farmers would have exhausted their previous season's farm proceeds, the possibility of larger farmers who are assumed to be wealthier to afford the high expenses is very negligible.

Proceeds from the cocoa farms was used as a proxy for the farmers' annual income and the distribution in terms of the number of bags of 62.5 kilograms weight per bag is presented in Table 4.18

Table 4.18: Distribution of Annual Income of Cocoa Farmers from Cocoa

Average number of bags	Estimated Income (¢'000)	Frequency	Valid %	Cumulative %
Below 20	5,480	142	47.3	47.3
20 – 40	5,480 - 10,960	62	20.7	68.0
41 – 60	11,234 - 16,440	30	10.0	78.0
61 – 80	16,714 - 21,920	23	7.7	85.7
Above 80	21,920	43	14.3	100.0
Total		300	100.0	

Source: Computation based on author's survey data.

Based on the estimated income from the number of bags produced, 47% of the farmers' cocoa proceeds fall below ¢5,480,000.00. Thirty-eight percent have annual incomes between ¢5,480,000.00 and ¢21,920,000.00 while only 14% of the farmers have proceeds above ¢21,920,000.00. The mean annual income of the sampled farmers is ¢10,275,000.00 (37.5 bags) and the mode is ¢5,480,000.00- ¢10,960,000.00 (20-40 bags).

With most of the farmers (47%) having annual incomes below ¢5,480,000.00 (20 bags), they are likely to be constrained by cash at the beginning of the season when the need to procure inputs for the application of the technology arises. Farmers' annual income from cocoa is an important determining factor in the adoption of the technology as their ability to acquire the inputs largely depends on it.

On labour from the household available to the cocoa farmers, the results indicate that about 52% have more than 2 household hands to assist on the farm (Table 4.19). The mean available household labour is 3 and the mode is 0-2. Eighteen percent have household labour ranging from 5 to 13. Availability of household labour is expected to encourage adoption of the technology considering the fact that labour is generally scarce in the rural areas due to the migration of the youth to the urban centres in recent years.

Table 4.19 Distribution of Household Labour Available to Cocoa Farmers

Available Labour	Frequency	Valid %	Cumulative %
0 – 2	145	48.3	48.3
3 – 6	139	46.4	94.7
7 – 9	11	3.6	98.3
10 – 13	5	1.7	100.0
Total	300	100.0	

Source: Computed from author's survey data.

The large household labour will be able to provide the necessary labour required for the provision of water and the spraying operations, especially in the case of the old and weak farmers.

The study also investigated the cocoa farmers' membership to associations and/or organisations, which as Degu (2000) puts it, "will put the farmer in a privileged position in terms of access to information and most importantly, financial assistance." Seventy-four percent of the sample indicated that they do not belong to any organisation or association that could offer any form of advice or assistance in their cocoa farming business. This is a true reflection of the fact that the farmers' groups and cooperative societies that existed some years back to assist farmers in the acquisition of credit and inputs are no more in operation. It is thus deduced that the remaining twenty-six percent of the farmers who indicated that they belong to some kind of associations might have misconstrued their membership with the cocoa buying companies as association membership.

Characteristics of adopters (farmers who did at least four sprayings a year for a minimum of two continuous years) and non-adopters are also compared using tests of equality of means, assuming equal variances (Tables 4.20). The differences between the means for household labour size and annual income turned out significant at the 1% level. This shows that the adopters sub-sample has, on the average, more family labour and higher annual incomes compared to their non-adopting counterparts. The other factors (age, experience and farm size) are not significant even at the 10% level.

Table 4.20: Comparison of Characteristics of Adopters and Non-adopters (Equality of Means Test)

Characteristics	Adopters	Non-adopters	t-value	Sig. (2-tailed)
Mean age	59.3	60.2	-0.639	0.523
Mean experience (yrs)	29.5	27.6	1.310	0.191
Mean farm size (Ha)	6.1	6.6	-0.747	0.456
Mean household labour	3.9	2.2	7.449	0.000***
Mean annual income (bags)	64.4	19.1	11.449	0.000***

Source: Culled from Appendix 2.
*** = Significant at 1% level.

The results of the non-parametric chi-square test in Table.21 culled from Appendix 3 indicate that the number of farmers with secondary level of education for the two categories is significantly different at the 1% level while the differences in the number of farmers with no education, secondary and tertiary levels of education are significantly different at the 10% levels respectively.

Table 4.21: Comparison of Characteristics of Adopters and Non-adopters (Chi-square Test)

Characteristics		Adopters	Non-adopters	Asymp. Sig, (2 tailed)
Gender	Male	83	140	0.056*
	Female	39	38	
No education		49	91	0.062*
Basic education		51	79	0.658
Secondary education		14	4	0.001***
Tertiary education		8	4	0.062*

Source: Culled from Appendix 3.
*** = Significant at 1% level.
*** = Significant at % level.

The difference in the gender of adopters and non-adopters is also significant at the 10% level. These show that adopters are generally better educated but tend to have fewer males compared to non-adopters.

4.9.2. Institutional Variables Affecting Adoption

The study also investigated some institutional factors that deal with the cocoa farmers' access to important services, which have great influence on the farmers' adoption behaviour. These include access to extension services, credit, inputs, and off-farm income.

On accessibility of extension to the cocoa farmers, only 17% indicated that they do not benefit from extension services in their cocoa farming operations (Table 4.22). Out of the 300 sampled cocoa farmers, 63% stated that they received more than 11 visits within a year. The maximum number of extension contacts in a year is 52 with a mean of 13 and a mode of 12-24 visits per annum. These findings suggest that extension contact is generally very good among cocoa farmers in the region as majority come into contacts with the extension agents at least every month.

Table 4.22: Distribution of Farmer-Extension Contacts

Extension contacts (visits)	Frequency	Valid %	Cumulative %
Less than 12	111	37.0	37.0
12 – 24	176	58.7	95.7
More than 24	13	4.3	100.0
Total	300	100.0	

Source: Computation based on author's survey data

Credit provision to cocoa farmers is generally very poor (Table 4.23) and this has been noted by Ampofo (1990). Out of the 300 sampled farmers, only 14% indicated that they normally get some form of credit ranging from ¢100,000.00 to ¢1,000,000.00. The mean amount received is ¢85,833.33 and the mode is ¢0-¢200,000.00. Eighty-eight percent of the farmers have credit, the value of which is less than ¢500,000.00. Access to credit by the cocoa farmers will help to relax their financial constraints and therefore enable them to procure the required inputs. The above findings indicate that cocoa farmers depend mostly on their own financial resources to undertake recommended practices. Considering that credit plays an important role in technology adoption, especially if the practice involves significant cash investment, this situation will impact negatively on the ability of the farmers to adopt the black pod disease control technology, which is viewed as costly.

Table 4.23: Distribution of Credit Among Cocoa Farmers

Amount of credit (¢'000)	Frequency	Valid %	Cumulative %
0 – 200	261	87.0	87.0
201 – 400	4	1.3	88.3
401 – 600	23	7.7	96.0
601 – 800	0	0	96.0
801 – 1,000	12	4.0	100.0
Total	300	100.0	

Source: Computation based on author's survey data.

On access to inputs in terms of availability and market distance (Table 4.24), 58% of the respondents indicated that the inputs are always available in the market at various locations and distances whenever needed while 42% stated otherwise.

Table 4.24: Distribution of Distance to Input Sources

Distance (km)	Frequency	Valid %	Cumulative %
Less than 9	83	27.7	27.7
9 – 16	82	27.3	55.0
More than 16	135	45.0	100.0
Total	300	100.0	

Source: Computed from author's survey data.

Twenty-eight percent (28%) of all the cocoa farmers have access to the inputs within a distance of 0.2 to 8 kilometres. Majority of them (45%) have to travel beyond 16 kilometres with 27% travelling between 8 and 16 kilometres outside their localities to procure the inputs. The mean distance to cover is 20.2 kilometres and the mode is 9-16 kilometres.

The above results also portray the situation on the ground in terms of the deficiencies in the distribution of sales points of cocoa inputs. The basic aim of privatising the sale of cocoa inputs was to make them easily accessible to farmers within their localities. The above results have proved otherwise as farmers' travelling distances have still not improved much. Meanwhile, access to input markets according to Sanginga (1998), is a critical force in driving farmers' adoption behaviour.

Affordability of inputs also contributes to their accessibility to the cocoa farmers. Sixty-eight percent of all respondents stated that they find the prices of the inputs to be on the high side and beyond their reach. This is not an encouraging situation for the adoption of the technology.

Non cocoa income, a proxy for off-farm income, helps to ease financial constraints and helps farmers to purchase inputs. Sixty-seven percent of the sampled farmers indicated that they have access to income outside cocoa proceeds (Table 4.25). Thirty-eight percent of the farmers have non-cocoa income forming more than 20% of their total annual incomes. The mean percentage annual income contributed from other sources other than cocoa is 20, and the maximum is 98.

Table 4.25: Distribution of Proportions of Farmers' Off-farm Incomes

Proportion of non-cocoa income (%)	Frequency	Valid %	Cumulative %
Below 20	186	62.0	62.0
21 – 40	81	27.0	89.0
41 – 61	21	7.0	96.0
61 – 80	6	2.0	98.0
Above 80	6	2.0	100.0

Source: Computation based on author's survey data.

These results suggest that most of the cocoa farmers in the region do not rely only on income from cocoa but have relatively high annual income supplementation from other sources, which may assist in inputs procurement and in effect, encourage adoption.

The study further makes a comparison of institutional variables and farmers' access to services between adopters and non-adopters (Table 4.26), using the t-test for equality of means (assuming equal variances). The means for extension visits, credit received and distance to the nearest source of inputs between adopters and non-adopters are statistically different at the 1% level of significance, while the means for the proportions of non-cocoa income are different at the 5% level. Thus, adopters are better off in terms of extension contacts, access to credit and shorter distances to input sources but have lower proportions of income from non-cocoa sources.

Table 4.26 Comparison of Access to Services by Adopters and Non-adopters

Variable	Adopters	Non-adopters	t-Value	Prob. of t-values
Mean extension visits	13.42	7.86	4.523	0.000***
Mean credit received (¢)	191393.44	13483.15	6.89	0.000***
Mean distance to inputs source	13.78	24.46	-6.44	0.000***
Mean proportion of non-cocoa income	16.05	21.87	-2.40	0.017**

Source: Culled from Appendix 2
*** = significant at 1% level.
** = significant at 5% level

4.9.3. Empirical Results of Factors Influencing Adoption of the Cocoa Black Pod Disease Control Technology in Ashanti Region (Logit Model)

In this section, the factors which influence cocoa farmers' decision to adopt or not are identified using the logit model. The specified logit model for explaining the factors that influence adoption of the cocoa black pod disease control technology is significant at the 1% level (probability of likelihood ratio of 0.00) with a likelihood ratio statistic of 304.55 (Table 4.27). This is an indication that the explanatory variables included in the model jointly influence the decision of the cocoa farmer to adopt the technology. The Mcfadden R^2 value of 0.75 also implies that the explanatory variables employed in the model accounted for 75% of the level of adoption.

Furthermore, the model predicted 93% of both adopters and non-adopters correctly (see Appendix 4). This makes it suitable for use in testing the validity of the hypothesis that the variables included in the model influence the adoption of the black pod disease control technology.

Table 4.27: Estimates of the Determinants of Adoption of the Cocoa Black Pod Disease Control Technology

Dependent Variable: ADOPTION
Method: ML - Binary Logit
Included observations: 300
Covariance matrix computed using second derivatives

Variable	Coefficient	Std. Error	z-Statistic	Probability Value	Elasticity of probability
AGEGROUP	-2.316223	0.855715	-2.706769	0.0068	-0.7755
GENDER	-1.895037	0.702265	-2.698465	0.0070	-0.5801
EDUC2	0.181609	0.683357	0.265761	0.7904	
EDUC3	2.470071	1.169158	2.112692	0.0346	0.0608
EDUC4	2.826893	1.665735	1.697084	0.0897	0.0473
EXPE	0.042152	0.033322	1.264978	0.2059	
FARMSIZE	-0.261730	0.091822	-2.850396	0.0044	-0.6898
OFAINCOM	-1.419815	0.617072	-2.300890	0.0214	-0.2231
HHLABSIZ	2.547223	0.633979	4.017836	0.0001	0.5395
COMEMBER	-0.108959	0.623054	-0.174878	0.8612	
NEXTVIS	2.724457	0.728846	3.738044	0.0002	0.7037
DISTINPU	-1.539833	0.660281	-2.332087	0.0197	-0.4377
INPUPRIC	-5.016538	0.869049	-5.772447	0.0000	-1.3920
ACCREDIT	2.360990	0.954010	2.474807	0.0133	0.1355
C	4.115411	1.661945	2.476261	0.0133	
Mean dependent var	0.406667	S.D. dependent var		0.492032	
S.E. of regression	0.233947	Akaike info criterion		0.436089	
Sum squared resid	15.59841	Schwarz criterion		0.621278	
Log likelihood	-50.41332	Hannan-Quinn criterion		0.510202	
Restr. log likelihood	-202.6867	Avg. log likelihood		-0.168044	
LR statistic (14 df)	304.5468	McFadden R-squared		0.751275	
Probability (LR stat)	0.000000				

Eleven explanatory variables are statistically significant in explaining cocoa farmers' adoption behaviour of the control technology. The annual farm income variable, though a very important factor in adoption decisions, was finally dropped because it was found to be highly correlated with farm size and gender. All the variables with the exception of 3 have the expected signs. The variables whose effects do not conform to the a-priori expectations include gender and non-cocoa income (off-farm income). The co-operative membership variable neither met the expected sign nor was it significant.

The negative coefficient for gender, which is significant at the 1% level, is an indication that female cocoa farmers are more likely to adopt the control technology than their male counterparts, all things being equal. This is contrary to expectations of the study and in contrast to most research findings (Adesina, 1999). Due to gender differences, certain agricultural tasks, such as the black pod control technology application, are allocated to only men (Mehra, 1994). However, with access to extension education, inputs and labour, women may also have the potential to adopt. Wolfson et al. (1990) observed in a study that women were much more likely to adopt cowpea preservation methods than their male counterparts. Women cocoa farmers generally have smaller farm sizes and so the total cash investment needed for input acquisition is not likely to overwhelm them. This is a factor that will encourage the women to adopt as compared to their male counterparts. Most of the women may also receive support from their husbands, which enhances their likelihood to adopt the technology. Dorris and Morris (2001) suggest that gender may play a role through other factors such as extension, access to credit and labour availability.

Farm size (FARMSIZE), which is significant at the 1% level, has generally been found to exert a negative influence on the decision to adopt technologies by farmers (Jabber, 1998; Nkonya et al. 1997), especially where it involves financial investment in inputs. Mussei et al. (2001) also show that adopters of improved wheat technology owned smaller farms, and explain the result in line with the lower investment in cost of inputs. The negative result is therefore a confirmation of the a-priori expectations of this study. This is explained that cocoa farmers with larger farms could be constrained by the high amounts required for investment in fungicides for the application of the technology. This is because large cocoa farms require large quantities of the fungicides for spraying at the beginning of the season when most of the farmers are financially constrained. However, farm size was found to be significant and positively related to adoption by Kherallah (2001), Doss and Morris (2001), Adesina (1996) and Sain and Martinez (1999).

Non-cocoa incomes, a proxy for off-farm income (OFAINCOM), does not show the expected sign though it is statistically significant at the 10% level. This confirms the fact that cocoa farmers use incomes from other sources as supplements to their farm incomes. In effect, they become satisfied and complacent and so gloss over the income losses they incur from their cocoa farms as a result of the black pod disease, which results in non-adoption of the control measures. This explains why some cocoa farmers in the Offinso/Akomadan and Bechem districts had to abandon their cocoa farms for maize, tomato and other vegetables due to the devastating effects of the disease on their cocoa proceeds and the favourable incomes from those ventures (Akrofi, 2000). Though this observation contrasts with general trends in adoption literature (Spencer, 1992; Mussei et al., 2001; and Degu et al., 2000), it is not an isolated case. Semgalawe (1998) found off-farm income earnings to be negatively related to adoption of improved soil conservation practices in Tanzania while Adesina (1996) found a similar effect on the adoption of fertilizer by rice farmers in Cote d'Ivoire.

The age variable (AGEGROUP) is significant at the 5% level and confirms the hypothesis that young farmers are less risk averse. Thus young and energetic cocoa farmers are more likely to adopt the control technology as compared to the old farmers. This corroborates the findings of Sain and Martinez (1999) in Guatemala and Manyong et al. (1998). Other researchers such as Adesina and Seidi (1995) and Onu (2001) also conclude that older farmers may have more skills but are less inclined to adopt than younger farmers. However, Mussei et al. (2001) and Kaliba (2000) find that older farmers were more likely to use new technologies.

The education variable turned out significant at the 5% level for secondary (EDUC3) and tertiary (EDUC4) levels of education. This confirms the hypothesis that better educated farmers are more likely to adopt technologies (IFPRI, 1995). Similar results have been reported by Nkonya et al. (1997), Dercon and Krishman (1998) and

Admassie and Asfaw (1997). Sain and Martinez (1999), however, found contrary results in Guatemala.

The hypothesis that the available household labour (HHLABSIZ) is positively correlated to adoption of the black pod disease control technology is confirmed. It turned out statistically significant at the 1% level, implying that the available labour from the family helps to alleviate labour constraints and reduce labour hiring costs for the farmers. This corroborates the findings of Demeke (1996) and Green and Ng'ong'ola (1993).

The extension contacts variable (NEXTVIS) shows the expected sign and is statistically significant at the 1% level. This is in line with general trends in adoption literature (e.g. Degu et al., 2001; Birkhaeuser et al., 1991 and Hounkpe, 1991).

Distance to the nearest input source (DISTINPU) and input prices (INPUPRIC) are both significant at the 5% and 1% levels, respectively, and show the expected negative signs. Khana (2001) reports that a 'major factor' affecting the participation in soil testing is proximity to input market, while Kheralla et al. (2000) show that market price of fertilizers has a negative effect on fertiliser use in Benin. Kalyebara (1999) also observes market access to be significant and negatively related to adoption of improved coffee management recommendations while Malton (1994) finds distance to input source to be negatively related to adoption in Burkina Faso.

Access to credit (ACCREDIT) has significant positive influence on the technology adoption at the 10% level. Credit use has generally been found to be very important in adoption literature. This is because, farmers are mostly financially constrained at the beginning of the season when the technology is to be used and so need some form of cash for use in procuring the inputs required for the application of the technology. Thus, the confirmation of the hypothesis that credit is positively correlated to adoption of the black pod disease control technology in this study is not surprising.

In evaluating the impact of the variables for future policy recommendations, it is inappropriate to interpret the coefficients as marginal effects on the dependent variable. Instead, weighted elasticities of the predicted probabilities of the explanatory variables which were computed using their means (see Appendix 5) are employed. The estimated elasticities are presented in the last column of Table 4.27. The estimates indicate that a policy change that would encourage a 10% increase in the proportion of the youth and women in cocoa production would lead to about 8% and 6% gains respectively in the probability of adoption of the control technology. Similarly, any policy that causes a 10% increase in extension contacts and credit has the potential to increase the probability of adoption of the technology by about 7% and 1%, respectively. Policies that would improve rural infrastructure and social amenities such that a minimum of 10% of the rural household labour could be retained also have the potential to increase adoption of the technology by about 5%. On the other hand, adoption would be expected to increase by about 4% and 14% if input prices and distance to the input sources are each reduced by 10%. Off-farm income could also be used to induce about 2% gains in adoption by policy if extension could work to conscientize the cocoa farmers to include part of their off-farm incomes in their investment portfolios for the acquisition of inputs. The elasticities for higher education though marginal (0.08 and 0.07), could also be a potential policy tool for increasing the probability of adoption of the technology.

CHAPTER 5

SUMMARY, CONCLUSION AND POLICY IMPLICATIONS

5.1. Summary

Cocoa production, one of the most important economic activities in the Ashanti Region of Ghana, has for sometime now been bedevilled with several problems. The most important of these is the black pod disease caused by the *Phytophthora megakarya* strain of fungus, which is destroying pods in large quantities and thus causing a substantial loss of incomes to the cocoa farmers. Research has made available a tried and tested control technology. However, widespread adoption of the technology has not accompanied its release and therefore, there is the need to study into the key determinants of farmers' decisions as far as adoption of these technologies are concerned.

Literature indicates that adoption of an agricultural technology is influenced by perceptions of the farmers about the technology, as well as their personal characteristics, socio-economic and institutional factors. The study therefore evaluates the cocoa farmers' awareness and perceptions about the black pod disease and the control technology, cost implications of using the technology, and uses an estimated index to examine the current extent of use of the technology in the region as well as the extent of use among adopters. Finally, the logit model is used to examine the factors which influence adoption of the technology.

It is found that cocoa farmers are generally aware of the negative impacts and the devastating effects of the black pod disease on their farms and on their farm incomes (profits). They are also fully aware of the recommendations for the proper application of the control technology. Cocoa farmers in the region perceive the control technology to be very effective and profitable, easy to understand (not complex), easily trialable with observable and demonstrable results. However, these positive appreciations are negated by their views that the technology is too tedious, time consuming and costly.

The perception that the application of the technology is expensive is confirmed by an estimated proportional cost contribution of 35% by the technology in the total production cost. It is the highest among the cost contributions of the most important practices recommended under the high level management technology.

Using an index of acceptability, the extent of use of the black pod disease control technology in the region by the cocoa farmers is estimated to be 15.8%, which indicates that the extent of use of the technology is very low in the region. Though the extent of use among adopters (75%) is encouraging, there is still the need for improvement considering that pod loss can be substantial and there is the possibility of inoculum build up on the remaining 25% untreated cocoa area, which will serve as a source of inoculum for re-infection of the controlled area.

Finally, the identified determinants of adoption of the cocoa black pod disease control technology are age, gender, education, farm size, off-farm income, available household labour, extension contacts, distance to input sources, input prices and access to credit.

5.2. Conclusions and Policy Implications

Based on the findings of the study in relation to the set objectives, it is concluded that there is the need for the government and all institutions and organisations especially, the stakeholders who are concerned with improvement in the cocoa industry to institute measures that will address the shortcomings of the technology. This way, cocoa farmers will be encouraged to accept the technology, which will lead to widespread adoption.

Firstly, the farmers' awareness and perception levels about the black pod disease and the control technology are very high and have significant effects on adoption of the technology. Extension therefore needs to work to sustain and even improve it so that it will form the basis of the farmers' understanding about the technology. Secondly, farmers' negative concerns about the technology need to be addressed with a view to changing these negative perceptions. The Cocoa Research Institute of Ghana, which is responsible for introducing innovations into the sector, needs to take a second look at the technology to make it less expensive and less time demanding. Thus, there is the need to improve the attributes of the technology that require the farmer to spray as many as 7 to 9 times in a season.

This study has shown that adopters of the black pod disease control technology were more literate, slightly younger, owned smaller farms, and had more family labour. Adopters also had more extension contacts, more access to credit and were closer to input sources. Female farmers were also more likely to adopt compared to nonadopters. The influences of the explanatory variables show that there are high chances of getting the cocoa farmers to adopt the control technology on large scale if policy is geared towards changing these parameters in a positive direction so as to remove any bottlenecks in favour of cocoa farmers. It is recommended that policy is directed at encouraging more of the educated youth into cocoa production by improving the rural infrastructure and paying attractive remunerative prices for the produce. This is because young and educated farmers are more likely to adopt the control technology.

Extension work as already stated, needs to be intensified but this time with a modification and repackaging of their message to focus on economic analysis (profitability) of applying the control technology. Farmers have hitherto assessed only the cost of inputs required for the technology application to be high, without weighing it against the value of the losses incurred from destroyed pods when control measures are not taken. Research-Extension-Farmer linkages should also be established and improved to effectively involve farmers in technology development.

It is very important to improve the inputs distribution network by opening more input stores in the rural areas, to bring them closer to the farmers in their localities. This was the main aim for privatising the sale of cocoa inputs in the country. The government also needs to revisit the inputs subsidy withdrawal issue with a view to re-introducing it as a means of reducing the inputs cost and in effect, the cost of application of the technology. This is seen as a possibility considering the huge sums of money being invested in the mass spraying exercise by the COCOBOD, which is already fraught with problems such as proper handling of the inputs as well as wider coverage of cocoa farms of the farmers.

Finally, the reorganisation of cocoa farmers into cooperatives and associations as existed in the late 1980s and early 1990s would go a long way to improve cocoa farmers' ability to access credit from both formal and informal financial sources. The executives of the associations would be able to lead the negotiations and guarantee for loans on behalf of their members.

Addressing these policy issues will encourage the farmers to take over the spraying of their farms, thus, leading to a more efficient way of controlling the black pod disease. This is because, more farms as well as more rounds of spraying would be covered in a season than is happening under the mass spraying exercise.

5.3. Suggestions for Future Research

Though, it is a fact that applying the technology to control the black pod disease and save the prospective infested pods is profitable, the details have not been scientifically worked out for the benefit of the cocoa farmers. Hence, there is the need to pursue a comprehensive research into the actual profitability per unit area of using the technology. This will take cognisance of the total cost of all inputs and labour required per unit area as against the value of pods that would be saved by the application of the technology, which would have otherwise been destroyed by the disease. This will be a good indicator of the benefits of adoption of the technology when well presented and explained to cocoa farmers in detail.

REFERENCES

Abdelmagid, S.A. and Hassan, F.K. (1996). "Factors affecting adoption of wheat production technology in the Sudan". *Quarterly Journal of International Agriculture*, Vol.35, No.4, Frankfurt, Main DLG-Verlag.

Adams, M.E. (1982). Agricultural Extension in Developing Countries. Longmann, England.

Adejobi, A.O. and Kormawa, P. (2002). Determinants of manure use in crop production in Northern Gui Zone of Nigeria. International Institute of Tropical Agriculture (11TA), Oyo Road, 5320 Ibadan, Nigeria.

Adesina, A.A. (1996). "Factors affecting the adoption of fertilizers by rice farmers in Cote d'Ivoire". WARDA, Bouake, Cote d'Ivoire. Nutrient Cycling in Agroecosystems, 46: 29-39.

Adesina, A.A. and Baidu-Forson, J. (1995). "Farmers' perceptions of new agricultural technology: Evidence from analysis in Burkina Faso and Guinea, West Africa". *Agricultural Economics* v.13, 1-9.

Adesina, A.A., Inaizumi, H. and Singh, B.B. (1997). Determinants of farmers' rapid adoption of improved cowpea varieties for dry season cultivation in northern Nigeria. Mimeo, IITA, Ibadan, Nigeria.

Adesina, A.A. and Seidi, S. (1995). "Farmers' perceptions of adoption of new agricultural technology: Analysis of modern mangrove rice varieties in Guinea Bissau". *Quarterly Journal of International Agriculture* 34: 358-371.

Adesina, A.A. and Zinnah, M. (1993). "Technology characteristics, farmers' perceptions and adoption decisions: a tobit model application in Sierra Leone", *Agricultural Economics* v.9: pp. 297-311.

Adhikary, Milan (1994). Determinants of fodder tree adoption in the mid-hills of Nepal. Ph.D. Thesis, AGS students.

Admassie, A. and Asfaw, A. (1997). The importance of education on allocative and technical efficiency of farmers: the case of Ethiopian smallholders. Paper presented at the 7th Annual conference on the Ethiopian Economy in Nazret (Addis Ababa: Addis Ababa Univ., Department of Economics, imeographed).

Adomako, D. (1990). "A review of research work at the Cocoa Research Institute of Ghana with particular reference to its impact on the small farmer". Proceedings of the 1st farming systems workshop. 5th –7th June 1990. pp. 5-13.

Agarwal, R. and Prasad, J. (1998). "Antecedents and consequences of user perception in information technology adoption". Decision Support Systems, 22 (1998). Elsevier Science, B.V., U.S.A

Ahenkora, Y. and Appiah, M.R. (1996). Promoting food security through soil fertility management in food and non-food crops. Proc., National Soil Fertility Action Plan.

Ahenkora, Y. Halm, B.J., Appiah, M.R. and Akrofi, G.S. (1981a). Fertilizer use on cocoa rehabilitation projects in Ghana. 8th Int. Cocoa Conf., 1981, Cartegena, Columbia, 165-170.

Akrofi, A.Y. (2000). "A review of phytophthora pod rot disease situation in Ghana". *Journal of the Ghana Science Association*, Vol.2, pp.218-228.

Akrofi, A.Y. and Opoku, I.Y. (2000). Managing phytophthora pod rot disease of cocoa: The Ghana experience. Proceedings of INCOPED 3rd seminar, 16th - 17th Oct., 2000. Kota Kinabalu, Sabah, Malaysia, Edited by Bong, C.L., Lee, C.H. and Shari; F.S. pp. 78-83.

Akrofi, A.Y., Opoku I.Y. and Appiah, A.A. (1997). "On farm farmer-managed trials to control black pod disease caused by *Phytophthora megakarya* in Ghana. Proceedings of the 1st International Cocoa Pests and Diseases Seminar, Accra 6th – 10th November 1997, pp. 109–118.

Akrofi, A.Y., Opoku, I.Y. and Appiah A.A. (1998). Extended interval of application of fungicides for the control black pod disease caused by Phytophthora megakarya in Ghana. Paper presented at the 2nd International Cocoa Pests and Diseases Seminar, Yamossoukro, La Cote d'Ivoire, 19th-24th January 1998.

Alao, J.A. (1973). "Community Structure and Farmers' Farm Practice Adoption". Bulletin of Rural Economics and Sociology, Vol. 8, No. 2: 281-312.

Alston, J.M., Norton, G.W. and Pardey, P.G. (1995). Science under scarcity. Principles and practice for agricultural research evaluation and priority setting. Cornell University Press, Ithaca.

Amemiya, T. (1981). "Quantitative Response Models". A Survey of Journal of Econometrics, 24: 3-6

Amir, K., Abadi, G. and Pannell D. J. (1999). A conceptual framework of adoption of an agricultural innovation. Agricultural and Resource Economics, University of Western Australia, 6907, Perth, Australia.

Ampofo, S.T. (1990). "Farmers' adoption of recommended practices. Farmer-Extension-Linkages" The first Farming Systems Workshop proceedings, 5th – 7th June 1990, pp.14-16.

Anderson J.R., Dillon, J.L. and Hardaker, J.B. (1997). Agricultural Decision Analysis. University of New England, Armidale.

Anthony, G. and Anderson, J.R. (1991). "Modeling technology replacement over time for ex-ante analysis of agricultural research projects". *Agricultural System* 37, pp.183-192.

Appiah, M.R., Ofori-Frimpong, K., Afrifa, A.A. (1996). Farmer fertilizer verification trials. Report of Cocoa Research. Institute. of Ghana, 1995/96: p.52

Appiah, M.R., Ofori-Frimpong, K., Afrifa, A.A. and Asante, E.G. (1997). "The prospects of fertilizer use in cocoa industry in Ghana". Proceedings, 15th Annual General Meeting, Soil Science Society of Ghana. Pp. 215-221.

Appiah, M.R., Sackey, S.T., Ofori-Frimpong, K. and Afrifa, A.A. (1997). "The consequences of cocoa production on soil fertility in Ghana: A review". *Ghana Journal of Agricultural Science*, 30, 183-190.

Appleton, S. and Balihatu, A. (1996). "Education and agricultural productivity: evidence from Uganda". *Journal of International Development*, Vol.8, No.3 pp.415-444

Asante, Emmanuel (2002). Determinants of adoption of improved technologies in cocoa production in Ashanti Region. M.Phil. Thesis submitted to the Department of Agricultural Economics and Agribusiness, University of Ghana, Legon.

Asante, E.G., Baah, F. and Adu-Acheampong, R. (2002). Preliminary report on monitoring of the mass spraying of cocoa in the Eastern, Central and Ashanti Regions. (Unpublished)

Asante-Kwatia, D. C., Adomako, D., Kpanyili, E., Dapaah, S., Hanson, J. W. and Kusi-Appiah, T. A. (2002). Report of the committee to investigate current problems of cocoa production with special reference to the spread and control of the black pod disease caused by *Phytophthora megakarya*. March 2002.

Asare-Nyarko, A. (1969). "The black pod disease of cocoa, a review of the situation in Ghana." In: Akrofi, A.Y. (Eds.), Review of the *Phytophthora* pod rot disease situation in Ghana. *Journal of the Ghana Science Association*, Vol.2 No.3, (2000): 218-228.

Asare-Nyarko, A. (1972). Sources of primary field inoculum of *P. palmivora* in cocoa fields in Ghana. Report of Cocoa Research Institute of Ghana, 1969-70, pp 65-68.

Asare-Nyarko, A. (1974). A comparison of fungicides for the control of the black pod disease of cocoa caused by *Phytophthora palmivora* (Butl.) In: A.Y. Akrofi (Ed.), A review of the Phytophthora pod rot disease situation in Ghana. *Journal of Ghana Science Association*, Vol. 2 No. 3, 2000, 218-228.

Asfaw, N.B.T., Franzel, S., Gemechu, G. and Lagesse D. (1991). "The introduction of an early maturing maize (Zeamays) variety to a mid-altitude farming system in Ethiopia". Exp. Agric., 27: 375-383.

Batz, F.J., Peters, K.J. and Janssen, W. (1991). "The influence of technology characteristic on the rate and spread of adoption". *Agric. Econ.* 21, 121-130.

Beck, R.L. and Gong, H. (1993). Adoption of Bovine Somatotropin by Kentucky Milk Producers. An Ex-ante Projection, Department of Agric. Econ., Bulletin No. 725, June 1993, Univ. of Kentucky, Lexington.

Bhalla, S. S. (1979). Farm size, productivity and technical change in Indian agriculture, agrarian structure and productivity in developing countries. Ed. R. Berry and W. Cline. Baltimore, John Hopkins Univ. Press, 1979.

Biggs, S.D. (1990). "A multiple source of innovation model of agricultural research and technology promotion". World Development 18, pp.1481- 1499.

Bindlish,V. and Evenson, R. (1993). Evaluation of the performance of T&V extension in Kenya. Word Bank Technical Paper 208, Africa Technical Department Series, World Bank.

Bindlish, V. and Evenson, R. (1997). "The impact of T&V extension in Africa: The experience of Kenya and Burkina Faso". Word Bank Research Observer 12 (2): 183-201.

Birkhaeuser, D., Evenson, R. and Feder, G. (1991). "The economic impact of agricultural extension: A review". Economic Development and Cultural Change, 39 (3), pp. 507-521.

Blencowe, J.W. and Wharton, A.L. (1961). Black pod disease in Ghana: Incidence of the disease in relation to productivity. Report of the 16th Commonwealth Mycological Conference, London, 1960, pp-147-189.

Bose, S. W. (1974). "The Comilla Co-operative approach and the prospects for broad-based Green Revolution in Bangladesh". World Development 2, no.8, Aug 1974. 21-28.

Brassier, C.M. and Griffin, M.J. (1979). "Taxonomy of *P. Palmivora* on cocoa transactions of the British Mycological Society". 72, 113-143.

Braun, J., von de Haen, J.and Blanken (1991). Commercialisation of agriculture under population pressure: Effects on production, consumption and nutrition in Rwanda. Research Report 85. Washington D.C. International Food Policy Research Institute.

Bronwyn, N.C. (1987). Cocoa: A trader's guide. Landell Mills Commodities Studies Limited.

Byerlee, D. and de Polanco, E.H. (1982). The rate and sequence of adoption of improved cereal Technologies: The case of rain fed barley in the Mexican Altiplano. Working paper 82/4. Centro International de Mejoramiento de Maiz y Trigo, Mexico.

CIMMYT Economics Programme (1993). "The Adoption of Agricultural Technology. A Guide for Survey Design". Mexico, D. F: pp.88. CIMMYT

COCOBOD (1993). 26th Annual Report and Accounts for the Year Ending 30th Sept., 1993, p.36. Ghana Cocoa Board, Accra.

COCOBOD (1994). Special Report, Task Force to Investigate Causes of Decline in Cocoa Production in Ghana and Measures to Revamp the Industry. Ghana Cocoa Board, Accra

COCOBOD (1998). Final Report, Cocoa Tree Stock Survey Project in Ghana. Project No. GCP/INT/632/COA, Ghana Cocoa Board, Accra, Ghana.

COCOBOD(2002). Report on cocoa purchases for the year ending 2000/2001. Monitoring, Evaluation and Projects Department, Ghana Cocoa Board, Accra, Ghana.

COCOBOD (2003). Report on Cocoa Statistics up to 2002, Research Department, Ghana Cocoa Board, Accra, Ghana.

Cocoa Research Institute of Ghana (CRIG) (1995). Guide to the control of black pod diseases. Guide to farmers No.9

Cocoa Services Division (1994). Annual report for the year ending Sept. 1993.

Collinson, M.P. and Tollens, E. (1994). "The impact of international agricultural research centres: measurement, quantification, and interpretation". Experimental Agriculture 30: 395-419.

Crider, A.B., Goethals, G.R., Kavanaugh, R.D. and Scott, P.R. (1989). Psychology. Solomon Scott, Foreman and Co., Glenview, Illinois.

Croppenstedt, Andre and Mulat, Demeke (1996). Determinants of Adoption and levels of demand for fertilizer for cereal growing farmers in Ethiopia. Centre for the Study of African Economies, Working Paper Series, 96-3

Daberkow, S. G. and McBride, W.D. (1998). "Adoption of precision Agricultural Technologies by U. S. Corn Producers". J. Agribus. 16:151-168.

Dakwa, J.T. (1974). The availability of *P. Palmivora* (Butl.) Butl. Inoculum for the development of cocoa black pod disease. In: Akrofi, A.Y. (Ed.), A review of the *Phytophthora* pod rot disease situation in Ghana. *Journal of the Ghana Science Association*, Vol.2 No.3 (2002), 218-228.

Dakwa, J.T. (1975). The importance of black pod disease in Ghana: Joint CRIG\Cocoa Production Division Project. Report, Cocoa Res. Inst. of Ghana, pp. 158-159.

Dakwa, J.T. (1976). Nationwide Black Pod Survey: Joint CRIG/Cocoa Production Division Project. Report, Cocoa Research Institute of Ghana, pp.71-72

Dakwa, J.T. (1977). The importance of black pod disease in Ghana: Joint CRIG/Cocoa Production Division Project. Rep., Cocoa Res. Inst. of Ghana, pp. 158-159.

Dakwa, J.T. (1978). Nationwide Black Pod Survey: Joint CRIG/Cocoa Production Division Project. Report of Cocoa Research Institute of Ghana, pp.181-182.

Dakwa, J.T. (1984). "Nationwide black pod survey: Joint CRIG/Cocoa Production Division Project". In: Akrofi. A.Y. and Opoku, I.Y. (Eds.), Managing Phytophthora megakarya pod rot disease: The Ghana experience, Proceedings of INCOPED 3rd Int. Seminar, 16th-17th October 2000. Kota Kinabalu, Sabah, Malaysia, pp.78-83.

Dakwa, J.T. (1987). "A serious outbreak of black pod disease in marginal areas of Ghana". Proceedings of 10th International Cocoa Research Conference, Santos Domingo, Dominican Republic, 17th –23rd May, 1987, pp 447-452.

Dakwa, J.T. (1988). "Changes in the periods for attaining the black pod disease infection peaks in Ghana". In: A.Y. Akrofi (Ed.), A review of *Phytophthora* pod rot disease situation in Ghana. *Journal of the Ghana Science Assoc.*, Vol.2 No.3, 2000,
pp. 218-228

Dankwa, J.B. (2000). Factors affecting the adoption levels of cocoa technologies in the Ashanti Region of Ghana. M.Phil. Thesis submitted to the Department of Agricultural Extension, University of Cape Coast, Cape Coast, Ghana.

Degu, G., Mwangi, W., Verkuijl, H. and Wondimu, A. (2000). "An Assessment of the adoption of seed and fertilizer packages and the role of credit in smallholder maize production in Sidama and North Omo Zones, Ethiopia". CIMMYT.

Dercon, S. and Krishnan, P. (1998). Changes in poverty in rural Ethiopia 1989-1995: a measurement, robustness tests and decomposition. Center for the Study of African Economies. Working Paper Series 98-97

Despreaux, D., Debost, M. and Nana, L. (1987). Study of cocoa black pod in Cameroon: Research into the links between the constituents of a pod and its susceptibility to *Phytophthora megakarya*. Proceedings, 10th International Cocoa Research Conference, Santo Domingo, Dominican Republic, 17-23 May 1987, pp 421-425..

Doss, C.R. and Morris, M. L. (2001). "How does gender affect the adoption of agricultural innovations? The case of improved maize technology in Ghana." *Agricultural Economics*. V. 25: pp.27-39.

Edwin, J.A. (1996). The adoption of improved rice varieties in inland valley swamps in Kambia and Port Loko Districts of Sierra Leone. A report presented at the 4th plenary session of the Rice Economics Task Force of West Africa (RETWA). WARDA, Bouake, Cote d'Ivoire. 5th-8th March, 1996.

Eicher, C.K. and Staatz, J.M. (1984). Agricultural Development in the Third World.

John Hopkins Univ. Press, Baltimore. In: J.A. Sterns and R.H. Bernsten (1994) (Eds.), Assessing the impact of cowpea and sorghum research and extension in Northern Cameroon. MSU International Working Paper No. 43

English, B.C., Roberts, R.K. and Larson, J.L. (2001). A Logit Analysis of Precision Farming Technology Adoption in Tennessee. Department of Agricultural Economics, University of Tennessee, Knoxville.

Engmann, S.C. (1993). An evaluation of production, marketing and utilization of soybean in Ghana: A case study of the Greater Accra Region. A B.Sc. dissertation submitted to the Department of Ag. Economy and Farm Management, Univ. of Ghana, Legon.

Evans, H. and Prior, C. (1987). "Cocoa pod diseases: Causal agents and control". *Outlook on agriculture*, vol.16, pp.35-41

Evenson, R. (1998). Economic impact studies of agricultural research and extension. mimeo, Yale University.

Feder G., Just R. E and Zilberman D. (1985). "Adoption of agricultural innovation in developing countries: A survey". *Economic Development and Cultural Change* 33: pp. 255-298.

Feder, G. and Umali, D.L. (1993). "The adoption of agricultural innovations. A Review". Technological Forecasting and Social change, 43, 215-239.

Fett, John (1971) "Education liberty, mass media exposure and farm practice adoption in Southern Brazil". *Rural Sociology* Vol.36 (1971): 359-366.

Fisher, A.J., Arnold, A.J. and Gibbs, M. (1996). "Information and the speed of innovation adoption". *American Journal of Agricultural Economics*, 78:1073-1081.

Fliegel, F. C. and Kivlin, J. E. (1966). "Farmers' perceptions of farm practice attributes". Rural sociology 31, 197-206.

Food and Agricultural Organisation (1986). Population and labour force in rural Economies. (FAO Economic and Social Development Paper No. 59, p.26)

Getahun D., Mwangi, W., Verkuijl, H., and Abdishekur, W. (2000). An Assessment of the adoption of seed and fertilizer packages and the role of credit in small-holder production of maize in Sidana and North Omo Zones, Ethiopia. Mexico, D.F.: International Maize and Wheat Improvement Centre (CIMMYT) and Ethiopian Agric, Research Organisation (EARO).

Ghadim, A., Abadi, K. and Pannell, D.J. (1999). "A conceptual framework of adoption of an agricultural innovation". *Agricultural Economics*, vol.21: 145-154.

Green, W.H. (1993). Econometric Analysis. New York, Macmillan Publishing

Company.

Green, D. A. G. and Ng'ong'ola, D. H. (1993). "Factors affecting fertilizer adoption in less Developed Countries: An application of multivariate logistic analysis in Malawi", *Journal of Agricultural Economics*, 44: 99-109.

Griliches, Z. (1957). "Hybrid corn: An exploration in the economics of technological Change". Econometrica 25(4), 501-522.

Gujurati, D.N. (1988). Basic Econometrics. 2nd Edition. New York, McGraw-Hill.

Hayami, Y. and Ruttan, V.W. (1985). Agricultural Development: An International Perspective. Revised Edition. Baltimore and London: Johns Hopkins University Press.

Henderson, C.P., Asante, E.G., Donkor, M.A., Ameyaw, K.O., Luterbacher, M.C., Akrofi, A.Y. and Boakye, P.D. (1994). Farmer managed fungicide trials (Volta and Brong Ahafo Regions). Rep., Cocoa Res. Inst., Ghana, 1991/92: 70-76.

Hiebert, Dean (1974). "Risk, Learning and the adoption of fertilizer-responsive seed varieties". *American Journal of Agric. Econ*. 56: 764-768.

Hildebrand, P.E. and Poey F. (1985). On-farm agronomic trials in farming systems. Lynne Rienner Publishers, Boulder, Colorado, U.S.A.

Hill, L. and Kau, P. (1973). "Application of multivariate probit to a threshold model of grain dryer purchasing decisions". *Amer. J. Agr. Econ*. 55: 19-27.

Hislop. E.C. and Park, P.O. (1960). "Fungicide research". Report of West Africa Cocoa Research Institute, 1960-61: pp. 96-106.

Honlonkou, A.N., Manyong, V.M. and Tchetche, N. (1999). "Farmers' perceptions and the dynamics of adoption of a resource management technology: The case of mucuna fallow in Southern Benin, West Africa". The Commonwealth Forestry Review, 1 (4), 1999, 228-235.

Hounkpe, E.R.C. (1999). Adoption of agricultural innovations: A case study of maize crib in Southern Benin. M.Phil. Thesis, Department of Agricultural Extension, Univ. of Ghana, Legon.

Hussein, S. and Byerlee, D. (1995). " Education and farm productivity in post 'Green Revolution' agriculture in Asia". In: G.H. Peters and D.D. Hedley (eds.), Agricultural competitiveness, market forces and policy choice, proceedings of the 22nd International Conference. of Agricultural Economists held in Harrare, Zimbabwe, 554-69.

Inaizumi, H., Singh, B.B., Sanginga, P.C., Manyong, V.M; Adesina, A.A. and

Tarawali, S. (1999). Adoption and impact of dry-season dual-purpose cowpea in the semi arid zone of Nigeria. Int. Inst. of Trop. Agric. (11TA), Ibadan, Nigeria.

International Cocoa Organisation (ICCO). Quarterly Bulletin of Cocoa Statistics, Volume 15, Number 4, 1998/99.

International Food Policy Research Institute (IFPRI). Women, the key to food security, Washington D. C., 1995

ISSER (2001). The State of the Ghanaian Economy, 2000. Institute of Statistical, Social and Economic Research, University of Ghana, Legon.

ISSER (2002). The State of the Ghanaian Economy, 2001. Institute of Statistical, Social and Economic Research, University of Ghana, Legon.

Jabbar, M.A., Beyene, Beyene, H., Mohammed-Saleem, M.A. and Gebreselassie, S. (1998). Adoption pathways for new technologies: An approach and an application to vertisol management technology in Ethiopia. Socioeconomic and Policy Research Working Paper No.23, Livestock Policy Analysis Project, International Livestock Research Institute, Addis Ababa, Ethiopia.

Jatoe, J.B.D. (2000). The determinants of adoption, impact of improved sorghum varieties in the Upper-West region, Ghana. M.Phil. Thesis, Department of Agricultural Economy and Farm Management, Univ. of Ghana, Legon, Accra.

Jones, A.M. (1989). "A double-hurdle model of cigarette consumption". *Journal of Applied Econometrics*, 4: 23-29.

Kaliba, A. R. M., Verkuijl, H. and Mwangi, W. (2000). " Factors affecting adoption of improved maize seeds and use of inorganic fertilizer for maize production in the intermediate and lowland zones of Tanzania". *Journal of Agricultural and Applied Economics*. Vol.32 (n.1). 35-47.

Kalyebara, Robert (1999). A comparison of factors affecting adoption of improved coffee management recommendations between small and large farmers in Uganda. Paper presented at the CIAT International Workshop: Assessing the Impact of Agricultural Research on Poverty Alleviation: San Jose, Costa Rica: 14-16 Sept. 1999.

Kamau, P.C. (1980). "Economics of herbicide use in coffee". Kenya-Coffee, 1980, 45:529, 111-119.

Kebede, Y., Gunjal, K. and Coffin, G. (1990). "Adoption of new technologies in Ethiopian agriculture: the case of Teguelet-Bulga District, Shoa Province". *Journal of Agicultural Economics* 4: 27-43

Kellam, M.K and Zentmyer, G.A. (1982). "Comparative survival of three

Phytophthora species pathogenic to cocoa in artificially infested soils". Proc., 8th Int. Cocoa Res. Conf., Cartegenia, Columbia, 18th-23rd Oct. 1982, pp. 499-504.

Kelly, V. (1988). Factors affecting the demand for fertilier in Senegal's peanut basin. Ph.D. Dissertation, Michigan State University, USA.

Kennedy, Peter (1998). A guide to Econometrics. Cambridge, MA, MIT Press.

Khanna, Madhu (2001). "Sequential adoption of site-specific technologies and its implications for nitrogen productivity: A Double Selectivity Model ". *American Journal of Agricultural Economics*, 83 (1): 35-51

Kherallah, M., Minot, N., Kachule R., Soule, B.G. and Berry P. (2001). Impact of Agricultural Market Reforms on Smallholder Farmers in Benin and Malawi. International Food Policy Research Institute.

Knepper, T.E. (2002). Factors affecting the use of fertilizer by small and medium-sized farming households in Zambia, 1997-2000. M.Sc. Thesis, Department of Agriculture and Natural Resources, Michigan State University.

La-Anyane, S. (1985). Economics of Agricultural Development in Tropical Africa. London. John Wiley and Sons Inc.

Leathers, H.D. and Smale M. (1995). "A Bayesian approach to explaining sequential adoption of components of a technology package". *American Journal of Agricultural Economics*, Vol.68, 519-527

Lin, C.A. and Jeffres, L.W. (1998). "Factors influencing the adoption of multimedia cable technology". J.M.C. Quarterly, Vol.75, No.2.

Lin, C.T.J.and Milon, J.W. (1993). "Attribute and safety perceptions in a double-hurdle model of shellfish consumption". *Am. J. Agric. Econ.* 75: 724-729.

Lindner, R.K. (1987). "Adoption and diffusion of technology: an overview", In: Champ, B.R., Highly, E. and Remenyi, J.V. (Eds.), Technological innovation in post harvest handling and transportation of grains in the humid tropics. ACIAR Proceedings No. 19, Australian Center for International Agricultural Research, Canberra, PP.144-151.

Lopez, C.P. and Requena, J. C. (2002). Adoption factors of the organic practices in the Southern Spanish Olive Farming: A logit model specification: Department of Agricultural Economy and Sociology, General Directorate of Agricultural Research of the Andalusian Government, Spain.

Lowdermilk, Max (1972). Diffusion of dwarf wheat production technology in Pakistan's Punjab. Ph.D. Thesis, Cornel University.

Luterbacher, M.L. and Akrofi, A.Y. (1993). "The current status and distribution of *P* *megakarya* in Ghana". In: J. de Lafforest (Ed.), Proceedings of the 11th Int. Cocoa Research Conf., Yamossoukro, La Cote d'Ivoire, 18th-24th July,1993, pp.29-35.

Marsh, S.P., Pannell, D.J. and Lindner, R. K. (1995). The adoption of iupins in Western Australia: Did extension make a difference? Paper presented at the 39th Annual conference of the Australian Agricultural Economics Society, Perth, Western Australia, February, 14-16, 1995.

MASDAR (1997). Socioeconomic study of the Ghana cocoa industry, Ghana Cocoa Board. Berks: Masdar House, Accra.

Matlon, P.J. (1994). "Indigenous land use systems and investments in soil fertility in Burkina Faso". In: Adesina, A.A (ed.), Factors affecting the adoption of fertilizer by rice farmers in Cote d'Ivoire, (1996). WARDA, Bouake.

Mehra, R. (1994). "Raising Agricultural Productivity: the Role of Women Farmers". In: Peters, G.H. and Douglas, D.H. (Eds.), Agriculture, Competitiveness, Market Forces and Policy Change. Proceedings of the 21st International Conference of Agricultural Economics, University of Dartmouth.

Melkote, S.R. (1997). Communication for Development in the Third World: Theory and Practice. Sage Publications. New Delhi/London

Million Tadesse, (2001). Determinants of Fertilizer use in Gununo Area, Wolaita Zone, Southern Ethiopia: An Application of logit Analysis. In Million, Tadesse and Getahun, Degu (Eds.), Review of on-farm research and adoption studies on maize in Southern Ethiopia (2001). Awassa Agricultural Research Centre, Ethiopia.

Ministry of Finance (1999). Ghana Cocoa Sector Development Strategy. Final report of the Task Force to evolve appropriate strategy for the development of the cocoa sector in Ghana, April, 1999.

Morris, C.G. (1985). Psychology: An Introduction. Prentice-Inc., England Cliffs, New Jersey.

Mussei A., Mwanga, J, Mwangi, W., Verkuijl H., Mungi, R. and Elang A. (2001). Adoption of improved wheat technologies by small-scale farmers in Mbeya District, Southern Highlands, Tanzania. Mexico, D.F.: International Maize and Wheat Improvement Centre (CIMMYT) and the United Republic of Tanzania.

Nell, W.T. (2000). Transfer and Adoption of Technology: The Case of Sheep and Goat Farmers in Qwaqwa. Ph.D. Thesis, Department of Agricultural Economics, Univ. of the Free State.

Negatu, W. and Parikh, A. (1999). " The impact of perception and other factors on the adoption of agricultural technology in the Movet and Jiru Woreda (Districts) of Ethiopia". *Journal of Agricultural Economics*. Vol. 21: 205-216.

Ngatia, S.C.E. and Kabaara, A. M. (1976). " The state of the Kenya Coffee industry, with reference to research and extension". Kenya-Coffee, 1976, 480, 94-99.

Njagi, S.B.C. (1980). "Economics of fertilizer use in coffee production. Nitrogen and Phosphates". Kenya-Coffee, 1980, 532, 219-33.

Nkonya, E., Schroeder, T. and Norman, D. (1997). " Factors affecting adoption of improved maize seed and fertilizer in Northern Tanzania". *Journal of Agricultural Economics*, V. 48 (n.1): 1-12.

Nowak, P.J. (1993). "Social issues related to soil specific management". In: P.C. Robert, R.H. Rust, and W.E. Larson (Eds.), Soil specific crop management, ASA Misc. Publ. ASA, CSSA, and SSSA, Madison WI.

Ntege-Nanyeenya, W., Mugisa-Mutetikka, M., Mwangi, W. and Verkuijl, H. (1997). An Assessment of Factors Affecting Adoption of Maize Technologies in Iganga District, Uganda. National Agricultural Research Organisation CIMMYT.

Onu, D. (1991). "Communication and adoption of improved soil conservation technologies by small scale farmers in Imo State of Nigeria". In Faye, J. (Ed.), Agricultural systems in Africa. *Journal of West Africa. Farming System Research Network.*

Opoku, I.Y. and Akrofi A.Y. (1995). The use of cultural practices and fungicide application in the management of black pod disease of cocoa caused by *Phytophthora megakarya* in Ghana. Paper presented at the 2nd National workshop on Food and Industrial Crops, Kumasi, Ghana, 24th-26th October, 1995.

Opoku I.Y., Akrofi, A.Y. and Afrifa, A.A. (1997). The spread of *P. megakarya* on cocoa in Ghana: Proc., 1st Int. Cocoa Pests and Disease Seminar, 6th-10th Nov., 1995, Accra, Ghana pp.98-107,

Opoku, I.Y., Akrofi, A.Y. and Asante A.A. (1995a). "The spread of *Phytophthora megakarya* on cocoa in Ghana". *Journal of the Ghana Science Association*, 2, (3), 110-116.

Opoku,I.Y., Akrofi, A.Y., Appiah, A.A. and Luterbacher, M.C. (1998). "Trunk injection of potassium phosphonate for the control of black pod disease of cocoa". Tropical Science vol. 38, pp.179-185

Opoku,I.Y., Akrofi, A.Y., and Appiah, A.A. (1999). "The spread of *Phytophthora megakarya* in Ghana". *Journal of the Ghana Science Association*, Vol.2, (3), pp.110-116.

Opoku, I.Y. and Owusu, G.K. (1995). "A severe type of black pod disease of cocoa in Ghana". CRIG Newsletter, 11, p.7.

Padi, B. and Owusu, G.K. (1998). Towards an integrated pest management for sustainable cocoa production in Ghana. Proceedings of the 1st Sustainable Cocoa Workshop, March 29-April 3, 1998. Panama.

Pannel, D.J. (1999). "Explaining non-adoption of practices to prevent dry land salinity in Western Australia: Implications for policy. Sustainability and Economics in Agriculture, GRDC Project, UWA 251

Photiades John D. (1972). "Motivation, contacts and technological change". *Rural Sociology*, No.127 (1972): 316-329.

Pinckney, T. (1995). Does Education Increase Agricultural Productivity in Africa? Mimeo, Department of Economics, Williamstown, MA: Williams College.

Pindyck, R.S. and Rubinfeld, D.L. (1998). Econometric Models and Economic Forecasts, 4th Edition. New York: McGraw-Hill.

Pisanelli, A; Franzel, S; De Wolf, J; Rommelse, R and Pooli, J. (2001). The adoption of improved tree fallows in western Kenya: Farmer practices, knowledge and perception. CNR, Istituto per l'Agroselvicoltura, Porano (TR), Italy; ICRAF, Nairobi, Kenya.

Prudentia,Y.C.(1983). A village study of soil fertility management and food crop production in Upper Volta: Technical and economic analysis. Ph.D. Dissertation, University of Arizona, Tucson. USA.

Readon,T.R, Crawford, E. and Kelly, V. (1994). "Links between non-farm income and farm investment in African households: Adding the capital market perspective." *American Journal of Agricultural Economics* 76 (5): 1172-1176.

Roberts, R.K., English, B.C. and Mahajashetti, S.B. (2000). "Evaluating the returns to variable rate of nitrogen application". *Journal of Agricultural and Applied Economics*, 32:133-143.

Rochin, R. I. (1973). "A study of Bangladesh Farmers' Experiences with IR-20 Rice Variety and Complementary Production Inputs". Bangladesh Economic Review, No.1 (Jan 1973): 71-94.

Rogers, E.M. (1962). Diffusion of innovations. New York: Sage.

Rogers E.M. (1995). Diffusion of innovations. 4th Ed. Free Press (Macmillan), New York.

Rosenzweig, M.R. (1995). "Why are there returns to schooling?" AER Papers, Proceedings of the American Economics Association, 85, 153-158.

Sanginga, C.P. (1998). Adoption and social impact of agricultural technologies: The case of soybean in Benue State, Nigeria. Ph.D. Thesis, Univ. of Ibadan, Nigeria.

Saha, A., Love, H. A. and Schwart, R. (1994). "Adoption of emerging technologies under output uncertainty". *Am. J. Agric Econ.*, 76: 836-846.

Sain, Gustavo and Martinez, Julio (1999). "Adoption and use of improved maize by small-scale farmers in Southeast Guatemala", CIMMYT Economics paper. V. 99, n.4.

Saito, K.A., Mekonnen, H. and Spurling, D. (1994). "Raising the productivity of women farmers in Sub-Saharan Africa". In: World Bank discussion Papers, Africa Technical Department Series, 230 p.39.

Saito, K.A. and Weideman, J. (1990). "Agricultural extension for women farmers in Africa". World Bank Discussion Paper No. 103. Washington D. C.

Schultz, T.W. (1964). Transforming Traditional Agriculture. New Haven: Connecticut, U.S.A. Yale University Press.

Scoones, I. and Thompson, J. (1994). "Knowledge, power and agriculture towards a theoretical understanding": In Scoones, I and Thomsom, J. (Eds.), Beyond Farmer First Rural Peoples' Knowledge and Extension Practice, London: Intermediate Technology Publication, pp. 16-32.

Semgalawe, Zainab (1998). Household adoption behaviour and agricultural sustainability in the northern mountains of Tanzania; the case of soil conservation in the northern Pare and West Usambara Mountains. WAU dissertation no. 2485.

Sharada, Weir (1997). Demand and supply constraints on schooling in rural Ethiopia. (Oxford: Center for the Study of African Economies, mimeo).

Sharada, Weir (1999). The effects of education on farmer productivity in rural Ethiopia. Centre for the Study of African Economies. Working Paper Series 99-7.

Shakya, P. B. and Flynn, J.C. (1985). "Adoption of modern varieties and fertilizer use on rice in the eastern terrain of Nepal". *Jr. Agric. Econ.*, 36: 409-419.

Shampine, Allan (1998). "Compensating for information externalities in technology diffusion models". *American Journal of Agricultural Economics*, V.80 (N.2): 337-346.

Shields, M.L., Rauniyar, C.P. and Goode, F.M. (1993). " A longitudinal analysis of factors influencing increased technology adoption in Swaziland, 1985-1991". *Journal of Developing Areas* (U.S.A), V.27 (4): pp.469-484.

Swanson B.E., Rolings, N. and Jiggings J, (1984). Extension strategies for technology utilization. In: Swanson, B.E. (Ed.), Agricultural Extension: A Reference Manual. F.A.O. of the United Nations, Rome.

Stoneman, P. (1983). The economic analysis of technological change. Oxford University Press, London.

`Tharold, C.A. (1974). "History up to 1930 of Black Pod and Other Cocoa Diseases caused by *P. palmivora*". In: P.H. Gregory (Ed.), Phytophthora Diseases of Cocoa, Longmans, London, pp. 13-21

Thirtle, C. G. and Ruttan, V.W. (1987). The role of demand and supply in the generation and diffusion of technical change. Hardwood Academic Publishers, London.

Trudy, O., Hoddinott, J. and Bill, K. (2001). The impact of agricultural extension on farm production in resettlement areas of Zimbabwe. Working Paper Series no.6, Centre for the Study of African Economies.

Tsur, Y., Sternberg, M. and Hachman, E. (1990). "Dynamic modelling of innovation process adoption with risk aversion and learning". Oxford Economic Paper, 42:336-355.

Waugh, R.K. (1982). A compendium of notes on farm focused research and extension. In: S.C. Engmann (Ed.), An evaluation of production, marketing and utilization of soybean in Ghana: A case study of the Greater Accra Region. B.Sc. Dissertation, Department of Ag. Econ. and Farm Management, Legon. (1993).

Wharton, A.L. (1962). "Diseases and pests of cacao: black pod and minor diseases". In: J. Brian Wills (Ed.), Agriculture and Land Use in Ghana, Oxford Univ. Press, London, pp, 333-341.

Willkie, H. (1991). System Theorie. Eiue Einfuhrung in die grand-probleme de theorie Sozialer systeme, UPB-Ver-lag, Stuttgart. In: F.J. Batz, K.J. Peters and W. Janssen (Eds.), The influence of technology characteristics on the rate and speed of adoption. *Journal of Agricultural Economics* 21 (1999) 121-130.

Wolfson, J.L., Murdock, L.L., Kitch, L.W., Shade, R.E. and Ntoukam, G. (1990). Preservation of post-harvest cowpeas by subsistence farmers in Cameroon. In Singh et al., (Eds.), Cowpea Research. Colourcraft, Hong Kong.

Wortman, C.B., Loftus, E.F. and Marshall, M.E. (1988). Psychology. Visual Education Corporation, Princeton, New Jersey.

Zepeda, L. (1994). "Simultaneity of technology adoption and productivity". Journal of *Agriculture and Resource Economics* (1994): 46-57.

Zinnah, M.M,, Compton, J.L. and Adesina, A.A. (1993). "Research-Extension-Farmer linkages within the context of generation, transfer and adoption of improved mangrove swamp rice technology in West Africa". *Quarterly Journal of Int. Agric.* (Germany). 32 (2). 201-214.

Appendix 1

DETERMINANTS OF ADOPTION OF THE COCOA BLACK POD DISEASE CONTROL TECHNOLOGY IN THE ASHANTI REGION, GHANA.

Questionnaire for farmer survey

Background: A Study of Socio-Economic, Technological and Institutional Factors Affecting the Adoption of the Cocoa Black Pod Disease Control Technology by Farmers in the Ashanti Region, Ghana.

- Please, fill in the blank spaces… or tick (√) where applicable, the answer of your choice.
- Where more than one possible answers are provided, choose the answer(s) which is/are applicable.
- Indicate N/A where the question does not apply to your situation.
- Kindly answer all questions.

Section A: General:

(a) Serial number of questionnaire…………… (b) Date……………………

(b) Cocoa District…………………………………… (c) Unit.. …………………..

Section B: Socio-economic Factors.

1. Age of cocoa farmer in years……………………………………..
2. Gender of farmer: (1) Male (2) Female
3. What is your educational level?
   (1) None (2) Non-formal (3) Basic (4) Secondary (5) Tertiary
4. For how long have you been a cocoa farmer? …………………… Years
5. What is the estimated size of your cocoa farm(s) in acres?
   farm 1:…………… farm 2: ………….. farm 3: ...………….
6. Approximately how many bags do you realise annually from your cocoa farm(s)?
   farm 1: …………..bags farm 2: ……………bags farm 3: ……………bags
7. Do you have any other source(s) of income apart from cocoa proceeds? (1) Yes (2) No
8. If yes, approximately what proportion of your annual income is contributed from these sources?……………………………………
9. What is the total number of members of your household? ………………………………...

10. How many of the household members actually work on your cocoa farm? ....

11. Do you have any cooperative societies related to cocoa operating in your area/district?
(1) Yes (2) No

12. If yes, are you a member of any of the cooperative societies? (1) Yes (2) No

Section C: Institutional Factors

13. Do you obtain educational information on cocoa production? (1) Yes (2) No

14. If yes, from where do you obtain your educational information on cocoa?
(1) Extension Agents (2) NGOs (3) Other farmers (4) Farmers' Groups
(5) Others (specify)....................

15. How often does the Extension Officer/Agent visit you as a cocoa farmer in a year?
(1) never (2) once a week (3) once a month (4) half yearly (5) once a year
(6) others (specify)...

16. Do(es) the Extension Officer(s)/Agent(s) discuss cocoa black pod disease problems with you? (1) Yes (2) No

17. If yes, does he/she talk about the recommended technology for controlling the disease?
(1) Yes (2) No

18. Do you have the black pod disease on your farm(s)? (1) Yes (2) No

19. If yes, were you spraying against the disease before the mass spraying exercise began?
(1) Yes (2) No

20. If no, give reason(s) (a) .... (b).......................... (c) ....

21. If you were spraying, how many continuous years did you do the spraying before the mass spraying began? (1) one (2) two (3) three (4) more than three

22. How many sprayings were you doing in a year? farm 1: .... farm 2:....... farm 3:.......

23. Approximately what area of the farm(s) in acres were you spraying?
farm 1 .... farm 2 .... farm 3 ....

24. Are the inputs for black pod control easily available when needed? (1) Yes (2) No

25. Approximately how far (miles) is the source of inputs?.....................................

26. How do you find the prices of the inputs? (1) High (2) Normal

27. Do you receive credit (cash or inputs) for your farm operations? (1) Yes (2) No

28. If yes, name the source(s). (1) Bank (2) Credit Union (3) NGOs ( )
(4) Cooperative Society (5) others (specify)...................................

29. Approximately how much credit do you receive annually for procuring inputs? ¢ ....

Section D: Cocoa Farmers' Awareness of the Control Technology

30. Indicate your awareness about the following recommendations of the control technology.

	Recommendations
When is spraying recommended to be started?	....
What is the spraying interval after first spray?	....
What are some of the chemicals for use?	....
What is the quantity of fungicide per tankful of water?	....
What type of machine is to be used?	....

COCOA FARMERS' PERCEPTIONS

Section E: Characteristics of the Cocoa Black Pod Disease as Perceived by Farmers.

31. Rank the following characteristics of the cocoa black pod disease, as you perceive them.

Characteristic	Completely disagree	Disagree	Indifferent	Agree	Completely agree
Prevalent in area	1	2	3	4	5
Poses danger to farm	1	2	3	4	5
Reduces farm income	1	2	3	4	5

Section F: Characteristics of the Control Technology as Perceived by Farmers.

32. Rank the following characteristics of the control technology, as you perceive them.

Characteristic	Completely Disagree	Disagree	Indifferent	Agree	Completely agree
Very effective	1	2	3	4	5
Not tedious in applying	1	2	3	4	5
Not time involving	1	2	3	4	5
Low initial cost	1	2	3	4	5
Easy to understand	1	2	3	4	5
Can easily be tried	1	2	3	4	5
Results easily demonstrable	1	2	3	4	5
Results easily observable	1	2	3	4	5
Profitable to apply	1	2	3	4	5

Section G: Production Costs Assessment

33. How many caretakers do you have? farm 1.......... farm 2.......... farm 3..........

34. How many times do you weed your farm(s) in a year?
(1) once (2) twice (3) thrice (4) four times

35. How many days do you use to do one complete weeding of the farm?
farm 1 .... farm 2 .... farm 3 ....

36. How many labourers do you employ to assist the caretakers to complete each weeding?
farm 1.................. farm 2...................... farm 3.....................

37. How much do you pay for each man-day of labour hired? ¢.........................

38. Do you control mistletoes and chupons on your farm? (1) Yes (2) No

39. If yes, approximately how many days does it take you to complete the whole farm?
farm 1............ farm 2............ farm 3..............

40. How much do you pay a day if you hire standard pruners for cutting the mistletoes?
¢..................

41. How many labourers do you employ each day? farm .... farm 2.... farm 3.....

42. How much do you pay for each man-day of labour hired? ¢....................

43. Do you prune your farm(s) annually? (1) Yes (2) No

44. If yes, how many days does it take you to complete pruning the farm(s) annually?
farm 1.............. farm 2.............. farm 3..............

45. How many labourers do you employ on each day? farm 1....... farm 2....... farm 3.......

46. How much do you pay for each man-day of labour hired? ¢..............................

47. If you were spraying against the black pod disease before the mass spraying, how many days were you using to complete spraying the farm(s)?
farm 1................ farm 2....................... farm 3......................

48. How many sprayers (machine operators) were you employing on each spraying day?
farm 1................ farm 2................ farm 3................

49. How much were you paying each sprayer for each manday? ¢.......................

50. How many water carriers were you employing during a day's fungicidal spray?
farm 1.................. farm 2..................... farm 3.......................

51. How much did you pay each water carrier for each man-day? ¢.....................

52. Do you use your own hand-spraying machine for fungicidal spraying? (1) Yes (2) No
53. If no, from where do you get your hand-spraying machine for fungicidal spraying?
(1) Hire at a cost (2) Collect from relatives at no cost

54. If you hire, how many machines do you hire on each spraying day?
farm 1:.................. farm 2:.................. farm 3:.........................

55. How much do you pay for a hired machine machine on a spraying day?
¢.................................

56. Do you spray against capsids on your farm(s)? (1) Yes (2) No

57. How many insecticidal sprayings do you do in a year?
farm 1 .... farm 2....................... farm 3.....................

58. How many days does it take you to do one complete spraying of the farm?
farm 1.................. farm 2.................... farm 3.................

59. How many machine operators do you employ on each spraying day?
farm 1..................... farm 2...................... farm 3......................

60. How much do you pay each machine operator for each man-day? ¢........................

61. How many water carriers do you employ on each spraying day?
farm 1..................... farm 2..................... farm 3.............................

62. How much do you pay each water carrier for each man-day? ¢...........................

63. Do you use your own motorised machine during spraying? (1) Yes (2) No

64. If no, from where do you get your motorised spraying machine for insecticidal praying?
(1) Hire at a cost (2) Collect from relatives at no cost

65. If you hire, how many machines do you hire on each spraying day?
farm 1:................ farm 2:........................ farm 3:............................

66. How much do you pay per machine per day? ¢..

67. Do you also apply fertiliser on your farm(s)? (2) Yes (2) No

68. If yes, how many days does it take you to complete applying the whole farm(s)?

farm 1................ farm 2.................. farm 3.......................

69. How many labourers do you employ on each day of fertiliser application?
farm 1.................. farm 2.................... farm 3..........................

70. How much do you pay each hired labourer? ¢...
71. Indicate the type and quantity of agrochemicals you normally use on your farm(s).

Type and Quantity of Agrochemicals	Farm 1	Farm 2	Farm 3
Name of insecticide used			
Quantity of insecticide used (litres)			
Name of fungicide			
Quantity of fungicide (satchets)			
Type of Fertiliser			
(a) Tripple superphosphate (bags)			
How much does a bag cost?			
(b) Muriate of potash (bags)			
How much does a bag cost?			
(c) Others (specify)			
What are their prices?			

72. How many times do you harvest in a year? farm 1.......... farm 2.......... farm 3.........

73. How many days does it take you to complete one harvesting on your farm(s)?
farm 1.................. farm 2.................... farm 3.............................

74. How many labourers do you employ during each harvesting? ....

75. How much do you pay each labourer per man-day? ¢.................................

76. How many days do you take to gather and heap the harvested pods? ....

77. How many hands do you employ to help caretakers during pod gathering and heaping?....

78. How much do you pay each employed hand per day? ¢.................................

79. How many hands do you employ during pod breaking and fermentation? ....

80. How much do you pay each employed hand for the day? ¢..............................

81. How many hands do you employ in carting the fermented beans home for drying? ....

82. How much do you pay each employed hand for the day? ¢.................................

83. How much do you incur in sending your produce to the selling depot? ¢...................

Appendix 2: Distribution of Sampled Cocoa Farmers

Districts	Units Selected	No. of Farmers Sample
Mampong	Bipoa	15
	Kona	15
	Wiamoase	15
	Abroma	15
Offinso	Asamankama	15
	Odeso	15
	Namong	15
	Abofour	15
Tepa	Nyamaa	15
	Camp 16	15
	Brosankro	15
	Amakrom	15
	Akwasiase	15
	Atobrakrom	15
Nkawie	Bayerebon	15
	Kyerekayaso	15
	Akotaa	15
	Akorabuokrom	15
	Otaakrom	15
	Anwiafutu	15
TOTAL	**20**	**300**

Appendix 3: Test of Equality of Means of Variables for Adopters and Non-adopters

T-Test

Group Statistics

	Farmer spraying at least four times for at least two continuous years	N	Mean	Std. Deviation	Std. Error Mean
Age of cocoa farmer in years	adoption	122	59.33	11.119	1.007
	non-adoption	178	60.20	11.983	.898
Cocoa farmer's working experience in years	adoption	122	29.49	10.253	.928
	non-adoption	178	27.58	13.653	1.023
Size of cocoa farms in hectares	adoption	122	6.1434	3.66676	.33197
	non-adoption	178	6.6225	6.40236	.47988
Household labour size of cocoa farmer	adoption	122	3.89	2.080	.188
	non-adoption	178	2.17	1.891	.142
Annual income of cocoa farmer in cedis from cocoa proceeds	adoption	122	64.3525	43.61797	3.94899
	non-adoption	178	19.1085	24.54625	1.83982
Annual number of extension visits in days to cocoa farmer	adoption	122	13.42	7.266	.658
	non-adoption	178	7.86	12.165	.912
Value of credit in cedis available to cocoa farmer	adoption	122	191393.4426	330832.44760	29952.16246
	non-adoption	178	13483.1461	79817.60455	5982.58240
Distance to the nearest source of inputs in kilometres	adoption	122	13.776	11.0219	.9979
	non-adoption	178	24.457	15.8936	1.1913
Proportion of income contributed from other sources	adoption	122	16.05	15.743	1.425
	non-adoption	178	21.87	23.327	1.748

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Age of cocoa farmer in years	Equal variances assumed	.205	.651	-.639	298	.523	-.87	1.368	-3.567	1.818
	Equal variances not assumed			-.648	272.347	.517	-.87	1.349	-3.530	1.782
Cocoa farmer's working experience in years	Equal variances assumed	15.139	.000	1.310	298	.191	1.91	1.456	-.957	4.772
	Equal variances not assumed			1.381	295.476	.168	1.91	1.382	-.812	4.627
Size of cocoa farms in hectares	Equal variances assumed	15.472	.000	-.747	298	.456	-.4790	.64168	-1.74184	.78378
	Equal variances not assumed			-.821	289.846	.412	-.4790	.58351	-1.62749	.66943
Household labour size of cocoa farmer	Equal variances assumed	.338	.561	7.449	298	.000	1.72	.232	1.269	2.181
	Equal variances not assumed			7.318	243.484	.000	1.72	.236	1.261	2.189
Annual income of cocoa farmer in cedis from cocoa	Equal variances assumed	52.128	.000	11.449	298	.000	45.2439	3.95168	37.46721	53.02068

proceeds	Equal variances not assumed			10.385	173.637	.000	45.2439	4.35654	36.64535	53.84253
Annual number of extension visits in days to cocoa farmer	Equal variances assumed	24.741	.000	4.523	298	.000	5.56	1.229	3.140	7.977
	Equal variances not assumed			4.944	293.062	.000	5.56	1.124	3.346	7.771
Value of credit in cedis available to cocoa farmer	Equal variances assumed	237.909	.000	6.893	298	.000	177910.2966	25811.16686	127115.04279	228705.55032
	Equal variances not assumed			5.825	130.705	.000	177910.2966	30543.79361	117486.11567	238334.47745
Distance to the nearest source of inputs in kilometres	Equal variances assumed	18.419	.000	-6.436	298	.000	-10.681	1.6596	-13.9470	-7.4151
	Equal variances not assumed			-6.873	297.951	.000	-10.681	1.5540	-13.7393	-7.6229
Proportion of income contributed from other sources	Equal variances assumed	11.555	.001	-2.404	298	.017	-5.82	2.420	-10.578	-1.054
	Equal variances not assumed			-2.578	297.943	.010	-5.82	2.256	-10.255	-1.377

Appendix 4: Chi-Square Test for Characteristics of Adopters and Non-Adopters

Non Parametric Tests (Mann-Whitney Test)

Ranks				
	farmer spraying at least four times for at least two continuous years	N	Mean Rank	Sum of Ranks
Gender of cocoa farmer	non-adoption	178	156.48	27853.00
	adoption	122	141.78	17297.00
	Total	300		
Cocoa farmers with no level of education	non-adoption	178	157.19	27979.00
	adoption	122	140.75	17171.00
	Total	300		
Cocoa farmers with basic level of education	non-adoption	178	152.07	27069.00
	adoption	122	148.20	18081.00
	Total	300		
Cocoa farmers with secondary level of education	non-adoption	178	144.87	25787.00
	adoption	122	158.71	19363.00
	Total	300		
Cocoa farmers with tertiary level of education	non-adoption	178	147.87	26321.00
	adoption	122	154.34	18829.00
	Total	300		

Test Statistics(a)

	Gender of cocoa farmers	Cocoa farmers with no level of education	Cocoa farmers with basic level of education	Cocoa farmers with secondary level of education	Cocoa farmers with tertiary level of education
Mann-Whitney U	9794.000	9668.000	10578.000	9856.000	10390.000
Wilcoxon W	17297.000	17171.000	18081.000	25787.000	26321.000
Z	-1.914	-1.866	-.442	-3.301	-1.868
Asymp. Sig. (2-tailed)	.056	.062	.658	.001	.062

a Grouping Variable: farmer spraying at least four times for at least two continuous years

Appendix 5a: Percentage Cost Shares of Recommended Practices at Farmer Levels (Complete Adoption of Recommended Practices)

	Weeding	Mistletoe control	Pruning	Capsid control	Black pod control	Fertilizer Application	Pods harvesting	Pods gathering	Pods breaking	Carting beans	Transporting Beans
	6.14	0.97	0.91	3.96	48.49	28.86	2.91	3.88	1.62	1.62	0.65
	10.92	1.76	1.95	11.90	29.71	34.58	3.12	1.95	1.56	1.56	0.99
	4.43	0.92	0.65	5.53	43.46	35.98	1.48	2.95	1.84	1.84	0.91
	5.44	2.81	2.03	17.63	28.93	28.94	3.48	4.64	2.18	2.18	1.74
	2.46	1.34	0.27	5.69	50.05	26.26	4.92	3.94	1.64	1.64	1.78
	3.30	2.25	1.20	10.75	40.76	27.93	4.52	4.01	2.41	2.41	0.46
	2.90	4.83	2.42	10.95	30.74	39.02	3.53	3.14	0.98	0.98	0.50
	5.40	3.15	0.30	7.05	38.38	20.99	3.60	2.52	9.00	9.00	0.63
	20.87	3.07	0.44	7.60	29.80	22.50	4.67	3.51	7.01	2.34	0.66
	2.92	0.47	0.21	2.40	23.34	21.91	20.03	18.41	5.22	2.61	0.02
MEAN	**6.48**	**2.16**	**1.04**	**8.35**	**36.37**	**28.70**	**5.23**	**4.90**	**3.35**	**2.62**	**0.83**
MAX.	**20.87**	**4.83**	**2.42**	**17.63**	**50.05**	**39.02**	**20.03**	**18.41**	**9.00**	**9.00**	**1.78**
MIN.	**2.46**	**0.47**	**0.21**	**2.40**	**23.34**	**20.99**	**1.48**	**1.95**	**0.98**	**0.98**	**0.02**
ST. DEV.	**5.63**	**1.47**	**0.85**	**5.03**	**9.61**	**6.52**	**5.30**	**4.81**	**2.95**	**2.72**	**0.60**

APPENDIX 5B

Percentage Cost Shares of Recommended Practices at Farmer Levels (Adoption of Recommended Practices Excluding Fertiliser Application)

Weeding	Mistletoe	Pruning	B.pod	Capsid	Harv.	Gathering	Breaking	Carting	Transp.
8.64	1.36	1.27	68.16	5.57	4.09	5.45	2.27	2.27	0.91
12.91	4.54	1.08	60.11	3.41	12.51	3.71	0.56	0.56	0.62
2.21	2.53	2.11	59.30	12.21	7.11	8.69	2.37	2.37	1.11
4.53	3.64	3.56	58.05	9.61	4.86	9.72	3.24	1.73	1.06
7.63	2.88	1.28	60.39	8.81	9.15	6.10	1.36	1.63	0.77
7.32	2.74	1.25	54.36	13.79	5.64	9.20	2.51	2.51	0.68
12.72	6.85	1.47	37.60	8.44	8.80	7.83	7.83	7.83	0.64
6.36	0.72	0.31	35.47	15.46	12.77	17.39	14.19	1.42	0.92
6.87	2.64	1.65	40.20	8.51	21.12	8.80	4.22	4.22	1.75
5.67	2.74	3.05	46.40	18.58	14.21	3.05	2.44	2.32	1.55
17.07	3.50	1.17	29.32	18.32	5.25	8.75	7.00	7.00	2.63
4.03	4.03	2.30	35.04	29.10	10.37	5.76	3.46	3.46	2.45
6.94	1.67	1.17	59.78	10.04	6.69	5.35	3.35	3.35	1.66
7.70	3.98	2.87	40.92	24.94	4.32	6.57	3.16	3.08	2.46
8.83	3.93	0.80	38.33	16.70	9.35	11.56	4.82	0.47	5.22
2.04	7.15	1.43	60.16	14.44	3.68	4.91	2.45	1.70	2.03
3.86	5.85	0.95	57.23	19.37	3.44	5.73	1.91	1.91	0.75
3.53	7.59	2.02	40.62	20.99	7.59	10.12	3.03	3.03	2.48
3.02	4.71	1.89	41.03	20.36	6.03	10.05	5.03	5.03	2.86
3.36	2.80	14.39	43.73	11.99	11.51	5.76	2.40	2.40	1.68
9.65	5.36	3.06	50.93	7.66	5.51	7.35	4.59	4.59	1.29
2.66	4.66	1.33	55.61	14.89	7.98	6.84	2.53	2.53	0.95
2.51	3.76	1.25	51.05	23.82	3.58	8.78	1.79	1.79	1.66
6.07	3.54	1.52	43.28	21.10	3.47	13.87	2.89	2.89	1.37
14.96	2.44	0.70	57.24	12.70	2.13	5.85	1.33	1.33	1.33
2.73	4.79	1.47	59.27	17.19	3.13	6.25	1.95	1.95	1.27
6.28	5.49	2.35	38.15	29.14	5.04	8.41	2.52	2.52	0.10
3.39	2.97	1.02	33.74	35.30	5.43	6.79	5.09	5.09	1.18
2.66	1.86	1.00	38.06	21.16	5.59	13.04	6.99	6.99	2.65
3.23	1.54	0.77	30.23	15.25	14.44	17.33	7.22	7.22	2.77
5.14	3.42	1.71	54.44	12.78	4.11	6.85	5.14	5.14	1.28
3.73	4.84	2.07	35.31	22.39	4.98	8.85	8.29	8.29	1.24
3.97	4.34	1.86	46.16	15.37	11.90	4.46	5.58	5.58	0.81
3.83	2.79	3.35	38.17	7.01	15.30	9.56	9.56	9.56	0.86
6.67	1.04	1.34	55.40	15.21	8.93	3.57	3.57	3.57	0.68
4.17	3.12	1.67	56.55	14.92	6.68	5.57	3.34	3.34	0.64
24.96	1.85	0.57	25.04	8.53	4.77	19.47	5.96	5.96	2.88
1.50	0.48	0.40	54.70	8.02	10.02	13.36	5.01	5.01	1.50
2.33	1.14	0.73	38.44	11.67	15.40	16.42	6.16	6.16	1.54
4.92	3.28	1.97	52.45	15.75	3.94	7.88	4.38	4.38	1.07
5.09	2.18	0.55	28.19	11.90	15.98	19.03	7.61	7.61	1.86
5.96	1.67	0.87	20.43	23.90	7.86	26.21	5.24	5.24	2.62
6.16	5.17	1.23	42.62	25.13	5.54	6.65	2.96	2.96	1.57
6.55	5.09	3.27	41.82	19.40	7.64	6.55	4.36	4.36	0.96
17.79	3.20	1.53	40.87	17.08	5.49	5.49	3.66	3.66	1.22

14.53	2.71	4.07	39.80	15.11	4.36	5.81	5.81	5.81	1.98
16.85	7.87	2.25	25.51	14.83	9.10	8.09	6.74	6.74	2.02
7.00	12.60	3.60	39.61	12.30	12.60	3.60	4.00	4.00	0.68
2.13	3.48	0.85	59.28	11.37	6.82	3.41	5.69	5.69	1.28
5.41	3.78	1.62	57.25	18.02	4.12	4.94	2.06	2.06	0.73
8.05	7.40	2.11	38.85	18.62	3.62	10.07	4.83	4.83	1.61
4.59	2.01	1.29	34.69	16.89	15.94	14.17	4.25	4.25	1.93
3.70	3.08	1.06	51.31	18.85	4.23	8.46	4.23	4.23	0.86
5.91	2.30	0.59	37.34	13.13	9.84	13.13	7.29	7.29	3.19
4.95	3.52	1.32	38.57	12.70	10.89	9.68	6.45	8.06	3.87
6.02	4.22	1.81	48.49	26.33	3.25	2.89	2.89	2.89	1.20
15.48	3.48	2.09	31.44	14.86	13.00	9.91	3.71	3.71	2.32
3.74	6.23	1.40	43.86	20.24	7.47	3.74	6.23	6.23	0.89
2.96	2.79	0.87	56.59	19.80	4.56	4.06	4.39	4.39	1.14
7.77	5.24	3.88	47.48	17.96	4.66	4.66	3.88	3.88	0.58
3.68	5.89	1.84	38.58	32.10	3.98	4.42	4.42	4.42	0.68
7.79	7.66	3.83	48.74	17.36	5.60	4.98	1.56	1.56	0.93
1.93	3.22	1.72	60.19	18.03	2.58	3.43	4.29	4.29	0.32
4.52	0.70	2.01	60.18	15.47	4.82	8.04	2.01	2.01	0.24
3.16	2.30	1.31	59.96	26.14	2.37	2.37	0.79	0.79	0.82
22.72	1.25	0.54	27.37	8.06	2.69	14.32	18.46	3.58	1.01
5.21	1.37	1.17	47.16	34.39	3.00	2.25	2.50	2.50	0.44
4.22	4.02	0.38	49.02	9.00	6.89	4.60	11.49	9.57	0.80
23.75	3.96	0.57	38.45	9.80	4.52	6.03	9.05	3.02	0.85
34.78	4.87	0.81	32.02	1.68	9.73	8.34	4.63	2.78	0.35
24.58	4.36	1.96	25.70	7.19	21.18	6.27	6.27	2.09	0.39
31.89	3.42	2.28	31.70	18.68	2.73	2.73	3.64	2.73	0.18
18.39	1.43	0.24	36.04	1.86	16.39	13.54	4.92	6.15	1.02
33.55	3.90	1.56	31.83	7.88	7.49	7.49	3.74	2.25	0.31
32.63	10.13	3.38	29.48	12.60	4.60	3.68	2.69	0.61	0.19
26.11	8.88	4.18	25.48	29.01	3.13	0.28	1.74	1.04	0.15
35.48	3.80	1.27	27.75	21.54	3.65	2.43	2.43	1.22	0.43
18.00	0.97	0.46	19.68	9.54	7.40	10.41	23.13	6.94	3.47
12.16	1.01	0.51	50.98	10.24	8.10	3.60	5.40	7.20	0.79
12.64	8.89	0.70	24.49	14.66	8.42	4.21	21.06	3.74	1.17
15.63	9.83	1.01	26.32	15.18	12.40	7.90	5.53	3.95	2.25
5.24	1.84	0.97	25.56	16.69	11.65	7.76	11.65	15.53	3.11
14.61	2.95	0.54	33.94	17.32	8.66	4.33	6.49	6.49	4.66
26.65	1.33	0.44	24.66	19.28	8.00	5.33	5.33	5.33	3.64
16.86	2.71	0.60	33.16	20.35	4.82	4.01	9.23	8.03	0.24
18.71	9.82	1.40	20.02	16.84	9.35	7.02	7.02	9.35	0.47
24.77	1.86	0.53	19.35	6.58	15.92	12.74	7.08	10.61	0.57
22.82	3.92	1.43	33.51	2.60	14.44	10.27	8.56	1.71	0.75
23.13	2.79	0.93	23.69	20.39	19.95	1.15	3.83	3.83	0.32
17.67	3.31	0.37	32.66	8.94	19.32	6.18	5.52	5.52	0.50
15.77	14.27	3.38	40.11	3.69	4.51	4.12	6.87	6.87	0.43
22.22	3.33	1.11	26.03	10.41	13.33	5.71	7.62	9.52	0.71
22.79	4.18	5.32	23.27	21.27	2.28	1.52	11.40	7.60	0.38
18.60	10.57	1.48	31.70	24.94	3.80	5.07	2.11	1.41	0.32
22.57	4.44	1.41	24.97	15.80	6.77	10.16	10.16	3.39	0.34
10.29	17.36	1.29	40.29	6.43	10.80	8.23	3.09	2.06	0.16
30.74	12.52	6.83	14.88	9.27	10.93	5.46	4.10	4.10	1.17

11.60	2.14	3.68	35.73	22.10	4.42	7.73	6.63	3.31	2.65
14.99	0.94	0.58	42.23	20.14	8.43	7.50	2.92	2.08	0.19
4.81	2.40	1.03	27.47	6.46	10.30	5.49	20.60	20.60	0.82
6.02	4.07	2.26	35.24	10.24	7.53	9.04	12.05	12.05	1.51
4.57	4.89	1.71	32.25	7.48	6.85	10.28	14.84	14.84	2.28
24.22	3.53	0.50	28.25	5.75	12.11	4.04	10.09	10.09	1.41
9.40	2.59	1.34	29.53	8.81	13.42	5.37	13.42	13.42	2.68
3.00	5.26	0.43	45.05	5.62	7.72	20.60	5.15	5.15	2.02
6.15	1.17	0.51	32.93	4.82	11.54	5.13	20.51	16.41	0.82
4.98	2.14	0.47	43.66	8.54	7.12	10.68	14.24	7.12	1.04
6.78	2.26	0.65	32.82	7.11	7.75	15.50	12.92	12.92	1.29
5.03	5.03	0.72	32.69	6.11	10.78	4.31	17.24	17.24	0.86
6.14	11.27	0.88	37.70	6.79	10.52	7.01	8.77	8.77	2.15
14.94	5.04	0.75	29.28	6.35	8.96	5.97	11.95	15.09	1.68
15.50	1.84	0.29	46.26	1.79	6.62	13.78	11.03	2.76	0.15
39.72	9.13	7.09	29.81	5.04	1.18	4.73	1.89	1.26	0.15
50.32	2.80	2.18	20.75	3.71	6.61	1.96	2.45	0.49	0.18
39.29	7.80	2.18	18.21	7.61	8.73	7.48	4.16	4.16	0.37
12.40	6.20	3.10	21.75	14.41	11.16	11.16	13.94	3.72	2.17
12.60	2.36	7.88	33.08	10.96	9.45	4.73	14.18	3.94	0.83
18.37	28.85	2.55	12.92	9.01	7.42	6.18	2.33	6.18	6.18
13.96	8.86	4.65	23.35	6.98	14.95	3.32	16.62	6.65	0.66
11.22	5.77	1.60	32.01	4.81	6.01	32.04	4.01	2.00	0.53
24.15	10.14	6.04	19.89	5.76	13.58	12.14	3.77	3.77	0.75
30.31	7.14	9.09	11.12	9.14	12.99	10.82	7.22	1.44	0.72
2.10	6.32	2.10	71.83	3.39	5.61	5.39	1.35	1.80	0.12
17.38	23.98	5.88	19.00	10.14	10.86	7.76	1.86	2.17	0.97
36.13	2.65	7.53	23.70	7.57	7.68	7.68	4.61	0.92	1.54
4.22	1.28	1.91	68.16	6.36	6.59	3.01	0.85	0.94	0.14
14.97	19.75	0.62	22.13	4.37	28.07	6.24	2.08	1.25	0.52
16.95	1.06	0.78	6.98	33.75	10.36	6.36	13.18	9.89	0.69
16.17	0.73	0.33	36.47	3.75	27.84	2.45	8.15	4.08	0.04
15.92	5.68	1.26	40.93	7.83	17.68	3.54	4.42	2.65	0.08
27.14	4.65	2.33	19.92	24.42	13.96	6.98	3.49	3.49	0.17
11.22	3.76	14.96	21.28	2.91	17.48	7.65	15.30	4.59	0.85
9.09	8.11	0.68	59.00	4.54	6.81	3.41	2.27	2.84	3.25
9.49	9.22	1.29	39.79	8.39	11.62	7.23	4.52	3.61	4.84
30.20	9.91	2.64	14.89	22.65	9.51	2.82	4.23	1.76	1.40
6.20	15.85	2.95	33.92	12.80	11.82	4.14	4.14	0.79	7.39
16.40	10.04	2.51	17.07	11.72	10.04	8.79	8.79	6.28	8.37
7.03	1.41	0.09	46.09	2.51	20.08	16.06	3.01	3.59	0.13
4.82	12.63	0.60	52.88	9.04	7.23	5.06	2.53	3.86	1.36
8.08	2.06	2.20	31.37	3.01	35.06	9.35	3.51	2.92	2.43
8.31	1.65	0.89	26.56	6.68	16.62	21.37	6.65	5.94	5.34
19.32	5.80	1.84	25.74	13.62	11.50	8.28	4.02	9.20	0.69
21.30	6.34	9.59	24.83	9.08	7.46	8.52	4.26	0.64	7.99
26.24	12.68	2.19	17.13	5.27	13.12	13.99	7.00	1.17	1.21
16.51	0.89	0.79	27.92	9.70	23.58	7.86	6.55	3.93	2.29
28.07	1.14	1.28	28.24	16.87	7.81	8.54	5.49	0.61	1.95
14.84	2.21	1.58	58.68	8.05	7.12	2.71	3.18	0.42	1.20
21.11	9.92	2.99	22.47	12.43	13.66	11.55	4.48	0.90	0.50
17.20	4.01	1.20	19.35	16.97	11.46	10.32	17.20	1.72	0.57

	33.38	5.17	1.94	17.08	10.35	10.35	3.88	11.64	3.88	2.33
	22.15	1.93	1.51	18.68	8.13	7.23	13.56	16.27	9.04	1.51
	18.61	4.65	0.97	32.76	5.16	8.38	9.31	5.82	13.96	0.39
	8.33	3.03	0.38	10.19	0.84	37.47	25.54	7.57	4.73	1.93
	49.73	2.49	2.90	15.33	4.81	8.36	6.10	5.43	4.52	0.33
MIN.	**1.50**	**0.48**	**0.09**	**6.98**	**0.84**	**1.18**	**0.28**	**0.56**	**0.42**	**0.04**
MAX.	**50.32**	**28.85**	**14.96**	**71.83**	**35.30**	**37.47**	**32.04**	**23.13**	**20.60**	**8.37**
MEAN	**13.22**	**4.94**	**2.05**	**36.80**	**13.13**	**9.37**	**7.98**	**6.26**	**4.79**	**1.46**
ST. DEV.	**10.30**	**4.27**	**2.21**	**13.92**	**7.41**	**5.86**	**4.94**	**4.61**	**3.70**	**1.44**

APPENDIX 6

Dependent Variable: ADOPTION
Date: 08/03/03 Time: 12:26
Sample: 1 300
Included observations: 300
Prediction Evaluation (success cutoff C = 0.5)

	Estimated Equation			Constant Probability		
	Dep=0	Dep=1	Total	Dep=0	Dep=1	Total
P(Dep=1)<=C	169	12	181	178	122	300
P(Dep=1)>C	9	110	119	0	0	0
Total	178	122	300	178	122	300
Correct	169	110	279	178	0	178
% Correct	94.94	90.16	93.00	100.00	0.00	59.33
% Incorrect	5.06	9.84	7.00	0.00	100.00	40.67
Total Gain*	-5.06	90.16	33.67			
Percent Gain**	NA	90.16	82.79			

	Estimated Equation			Constant Probability		
	Dep=0	Dep=1	Total	Dep=0	Dep=1	Total
E(# of Dep=0)	162.67	15.33	178.00	105.61	72.39	178.00
E(# of Dep=1)	15.33	106.67	122.00	72.39	49.61	122.00
Total	178.00	122.00	300.00	178.00	122.00	300.00
Correct	162.67	106.67	269.34	105.61	49.61	155.23
% Correct	91.39	87.43	89.78	59.33	40.67	51.74
% Incorrect	8.61	12.57	10.22	40.67	59.33	48.26
Total Gain*	32.05	46.77	38.04			
Percent Gain**	78.82	78.82	78.82			

*Change in "% Correct" from default (constant probability) specification
**Percent of incorrect (default) prediction corrected by equation

APPENDIX 7

Dependent Variable: ADOPTION
Method: ML - Binary Logit
Date: 08/03/03 Time: 12:26
Sample: 1 300
Included observations: 300
Descriptive statistics for explanatory variables

Variable	Dep=0	Mean Dep=1	All
AGEGROUP	0.904494	0.688525	0.816667
GENDER	0.786517	0.688525	0.746667
EDUC2	0.443820	0.418033	0.433333
EDUC3	0.022472	0.114754	0.060000
EDUC4	0.022472	0.065574	0.040000
EXPE	27.58427	29.49180	28.36000
FARMSIZE	6.622472	6.143443	6.427667
OFAINCOM	0.432584	0.311475	0.383333
HHLABSIZ	0.359551	0.745902	0.516667
COMEMBER	0.258427	0.262295	0.260000
NEXTVIS	0.410112	0.950820	0.630000
DISTINPU	0.837079	0.483607	0.693333
INPUPRIC	0.971910	0.245902	0.676667
ACCREDIT	0.028090	0.303279	0.140000
C	1.000000	1.000000	1.000000

Variable	Dep=0	Standard Deviation Dep=1	All
AGEGROUP	0.294741	0.465006	0.387586
GENDER	0.410922	0.465006	0.435647
EDUC2	0.498235	0.495270	0.496364
EDUC3	0.148631	0.320039	0.237884
EDUC4	0.148631	0.248556	0.196287
EXPE	13.65251	10.25320	12.40012
FARMSIZE	6.402361	3.666759	5.455426
OFAINCOM	0.496832	0.465006	0.487011
HHLABSIZ	0.481222	0.437148	0.500557
COMEMBER	0.439005	0.441696	0.439367
NEXTVIS	0.493241	0.217136	0.483611
DISTINPU	0.370336	0.501792	0.461880
INPUPRIC	0.165696	0.432396	0.468530
ACCREDIT	0.165696	0.461570	0.347567
C	0.000000	0.000000	0.000000
Observations	178	122	300