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Financial Impact Analysis of IPM with Conventional Sampling and IPM with Binomial Sequential Sampling Method to Traditionally Operated Farms for Collards, 2007

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FINANCIAL IMPACT ANALYSIS OF IPM WITH CONVENTIONAL SAMPLING AND IPM WITH BINOMIAL SEQUENTIAL SAMPLING METHOD TO TRADITIONALLY OPERATED FARMS FOR COLLARDS, 2007

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ABSTRACT

Integrated Pest Management (IPM) has been very successful in directing farming to a more environment-friendly production. However, the extent of its economic impact is an equally-important question. This study looks at the amounts of savings and potential market profitability of using IPM in South Carolina collard production considering alternative scouting methods. Conventional sampling (CS) and binomial sequential scouting method (SSM), a recently developed scouting system for traditionally operated collard farms are compared. SSM is geared towards a more economical execution of scouting without forfeiting the effectiveness of the process. Financial analysis specifically costs and returns methods and sensitivity analysis on prices were utilized to determine the economic advantages or disadvantages of the two methods.

The outcome of the study showed that both scouting methods would result in cost savings if used on traditionally operated farms. Particularly, the cost savings generated from IPM with SSM (3.62 percent of total cost and 3.91 percent of total variable cost) is higher than the cost savings from IPM with CS (2.91 percent of total cost and 3.15 percent of total variable cost). The difference in cost savings between IPM with CS and IPM with SSM basically came from the less scouting time of SSM thus lower labor cost for the farm. Therefore, to attain maximum profitability potential, using IPM with the sequential scouting method is a better option. Some may conjecture that the

cost savings were insignificant because the percentages are low. However, the importance of these cost savings grows after taking account of the potential savings per farm and at the aggregate state level.

Implementing IPM on the farm not only offers cost savings but opens the possibility of higher sales price. IPM products can be sold at 5 to 10 percent price premiums over regular or uncertified products. There is a fee for certification but the benefits overshadow the costs.

In summary, findings show that IPM with conventional sampling and IPM with sequential sampling are both cost-effective and profitable, thus having positive impacts not only environmentally but also economically. Both methods are great tools in a transition program to organic farming. Clearly when considering the potential for maximum profits, IPM with SSM is the preferred choice.

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TABLE OF CONTENTS

Page

TITLE PAGE ... i

ABSTRACT ... ii

ACKNOWLEDGMENTS ... iv

LIST OF TABLES ... viii

LIST OF FIGURES ... x

CHAPTER

I. INTRODUCTION ... 1

Background and Statement of the Problem ... 1
Significance of the Study ... 3
Objectives ... 6
Conceptual Framework ... 7

II. REVIEW OF RELATED LITERATURE ... 10

Why Collards? ... 10
Pest Control Practices: A Deeper Look ... 10
Current Pest Management Programs ... 13
Bio-based Pest Management ... 13
Invasive Species ... 14
Pesticides ... 15
Integrated Pest Management (IPM) ... 16
Related Economic Analyses on IPM ... 19
The IPM Continuum ... 21
Pest Manager / Ecosystem Manager ... 22
Pest Identification and Monitoring (Scouting) ... 22
Economic Threshold and Economic Injury Levels ... 28
Inherent Cost Issues on Beneficial Insects and Pest Resistance ... 28

Table of Contents (Continued)

Page

IPM Products Certification 30
Benefits of Pesticides 31
Limitations of the Study 32

III. METHODOLOGY 33

Scope and Area 33
Data Sources 33
Analysis Methods 34
Tabular, Graphical and Descriptive Analysis 34
Costs and Returns Analysis 34
Sensitivity Analysis on Profitability 35

IV. RESULTS 37

The Farm and the Farmers 37
Non-IPM Farms 38
Conventional and Sequential Sampling Methods 40
Changes in Input Costs Attributable to Different Scouting Methods 42
Conventional Scouting 42
Sequential Scouting Method 49
Comparison of the Net Impacts of CS and SSM Relative to Non-IPM Farms and Between CS and SSM System 50
Whole Farm Effect and State-Level Savings 53
IPM Product Certification Scenario 56
Sensitivity Analysis 57

V. SUMMARY AND CONCLUSIONS 61

Recommendations 64

REFERENCES 66

LIST OF TABLES

Table		Page
2.1	Frequency of occurrence of terms or expressions used in 67 definitions of IPM compiled in the Compendium of IPM Definitions	18
2.2	Sampling Form for Insects of Cabbage and Collards	27
4.1	Comparison of Scouting Time and Precision of Spraying Decision Between Conventional and Sequential Scouting Per Acre, Sept – Oct 2007	40
4.2	Collards – Irrigated (Hand Harvest) Estimated Costs and Returns Per Acre, 2006/2007	43
4.3	Chemical Use Assumptions for Collards (Non-IPM Farms)	44
4.4	Per Acre Machinery and Labor Requirements for Collards (Non-IPM Farms)	44
4.5	Collards – Irrigated (Hand Harvest Using Conventional Scouting) Estimated Costs and Returns Per Acre, 2007	46
4.6	Chemical Use and Other Pest Protection Assumptions for Collards (IPM Farms with CS and SSM)	47
4.7	Per Acre Machinery and Labor Requirements for Collards (IPM Farms with CS and SSM)	47
4.8	Collards – Irrigated (Hand Harvest Using Sequential Scouting) Estimated Costs and Returns Per Acre, 2007	51
4.9	Per Acre Savings Between Different Systems by Type of Cost	53
4.10	Savings Between Different Systems by Type of Cost	55

List of Tables (Continued)

Page

4.11 Sliding Scale of Annual Certification Fee in Terms of Percentage of Gross Sales 56

4.12 Break-even Price Per Box Under Different Points of Production 57

4.13 Baseline Profits (Non-IPM System) 58

4.14 Sensitivity Analysis on Profit – IPM with Conventional Scouting System 58

4.15 Sensitivity Analysis on Profit – IPM with Sequential Scouting System 59

4.16 Minimum Price and Percent Changes Necessary to Cover Additional Cost Due to Certification 60

LIST OF FIGURES

Figure Page

1.1 Schematic diagram of the difference in the three methods as a process in planting 8

1.2 Graphical representation of production and cost relationship 9

2.1 Suggested walking pattern for filed sequential sampling 25

4.1 Percentage Share of Variable Inputs in Total Variable Cost 39

4.2 Time Spent on Scouting Per Visit, 2007 41

CHAPTER I

INTRODUCTION

> *"It should be evident that no economic system can be regarded as stable if its operation strongly violates the principle of ecology. …both socialist and capitalist theory have apparently developed without taking into account the limited capacity of the biological capital represented by the ecosystem. As a result, neither system has as yet developed a means of accommodating its economic operation to environmental imperatives. Neither system is well prepared to confront the environmental crisis; …nature is not 'the enemy,' but our essential ally. The real question is to discover what kind of economic and social order is best adapted to serve as a partner in the alliance with nature."*
>
> \- *Barry Commoner,*
> *"Closing the Circle," 1971*

Background and Statement of the Problem

Susceptibility to natural occurrences is one of the biggest challenges faced by agriculture. Pests and plant diseases could be counted as one of the most important constraints in production of marketable products in general, and specifically for cabbage, collards and other cole crops (IPM for Cabbage and Collard, A Grower's Guide-Clemson Extension, 2005). In response to these, many research efforts have been conducted. Currently there are four pest management programs specified by the United States Department of Agriculture (USDA): Bio-based Pest Management (BPM), Integrated Pest Management (IPM), Invasive Species (IS) and Pesticides of which the latter has become the conventional practice by most farmers. It has become common practice because it is relatively inexpensive, easy, and effective in meeting market demands for a blemish free crop.

On the other hand, consumers are becoming concerned for healthy lifestyles, and obviously crops grown using a synthetic pesticides may pose health concerns. Therefore, conventionally produced crops are losing their market potential. Since healthy living is in the spotlight, the demand for healthy food is growing rapidly. In response to consumers' preference of pesticide free food and producers' inability to get rid of pesticides without significant yield loss, using IPM on the farm has become a viable alternative. IPM is the product of research that both lowers pesticide application and at the same time controls pest infestations. Integrated Pest Management is an ecologically-based approach to managing pests with emphasis on natural and cultural control processes and methods, including host plant resistance and biological control. Because the focus is on prevention, avoidance, monitoring and suppression of pests, chemical pesticides are used only where and when these measures fail to keep pests below damaging levels (Clemson University-IPM Program). The goal is to minimize economic, health and environmental risks.

Pest identification and use of pesticide action thresholds to signal spraying actions form the essence of IPM because it is where the decision whether pesticide use is necessary or not is made. Information needed on pest identification and pesticide action thresholds are gathered through scouting which makes this task very crucial. However, this activity is also time consuming; thus farms often do it inappropriately or totally skip the process and just go ahead and spray.

A conventional way of scouting already exists, but Smith and Shepard published a study in 2005 in relation to the IPM Program and scouting in collards where they designed a new way to scout the fields. They called it binomial sequential sampling method (SSM) and concluded that this way of scouting for pests is more time efficient and as precise as the conventional method. It is suggested in the *IPM for Cabbage and Collard, A Grower's Guide,* as well as other studies, that it will significantly reduce production costs and ultimately increase net benefits to farmers. However, rigorous economic studies have not been conducted to support this claim. In this light, the economic analysis was done comparing the cost effectiveness of both scouting methods on traditionally operated farms.

Significance of the Study

Since much of agriculture is in a stage of transition away from chemical-based inputs, breakthroughs on farm activities helping the gradual alteration of the whole farming system to an environment friendly production are very valuable. Such changes brings agriculture one step closer to its desired goal of being sustainable. Aside from environmental health, economic profitability and social and economic equity are the main goals of sustainable agriculture (Anonymous-Penn State News Releases, 2005).

The quality of conventional scouting and the precision and efficiency of sequential scouting under Integrated Pest Management were already proven ecologically and scientifically. Since these practices affect factors of production, relevant impacts on costs are extremely crucial specifically to the producers. In essence, the purpose of this study is to examine the economic profitability of these farm activities relative to traditional farming methods.

Smith and Shepard found a 75 percent or more reduction on samples needed from conventional sampling to sequential sampling were possible. Does the reduction in time and number of samples translate directly to the costs? How about the cost reduction brought on by conventional sampling? An economic analysis would help in letting the producers understand and adapt the practice given the fact that they can visualize the materialized benefit in dollar terms.

In compliance with one of their major goals -a workable plan with commercial application- Smith and Shepard reiterated what Trumble stated in 1994, "Finally, the available literature is filled with papers describing sampling plans that will never be used commercially; failure to validate a proposed sampling plan in large-scale commercial operations is probably the single most important reason that such plans are not adopted." Therefore to validate the propositions and push commercial adoption, the empirical results given here can be used to provide key information on SSM to farmers through extension programs. And in subsequent studies adjustments to the new scouting design can be made to make it more economical.

Also, too much pesticide use is now considered unacceptable to consumers due to increasing concerns regarding health issues. Organic farming is growing to meet this change in demand. However, organic farming entails higher costs due to the labor intensive activities involved. In addition, much of the shift to reducing dependence on chemical inputs is occurring on relatively small farms which lack the benefit of economies of scale. As a result consumers must pay higher prices or producers will not be able to compete. Several technical innovations especially to reduce the labor intensiveness of organic farming will narrow the gap between smaller organic farms and large-scale conventional operations. Meanwhile, in the phase of agricultural transition, a gradual approach provides a means to adapt without fully and abruptly changing the current operations of the farm. Integrated Pest Management with an efficient scouting method is one of the means to achieve this goal.

Results of this study will help to identify if using IPM with conventional or sequential sampling method is cost effective thus reducing farm costs by eliminating the unnecessary use of pesticides. In this fashion, pesticide use will be minimized and farming will be more economical and environment friendly, and higher quality products will be available to the market.

Objectives

The study was conducted to determine the financial impacts of IPM with conventional scouting and IPM with sequential scouting method on South Carolina collard farms using traditional pest management operations.

Specifically it aims to:

1. evaluate the three systems being compared;
2. determine the cost and returns of producing collards using IPM with conventional scouting and IPM with sequential scouting;
3. determine the cost reduction from non-IPM to IPM with conventional scouting and from non-IPM to IPM with sequential scouting;
4. examine the effect of IPM product certification on profits and inspect profitability response to price changes;
5. discuss the impacts on society, specifically for producers and consumers; and
6. provide appropriate recommendations.

Conceptual Framework

Traditional practices for collard production are extensively known and commonly used thus instead of conducting an experiment to gather traditional operation costs, the standard budget for collard production was used. In order to evaluate the effect of the two scouting methods under Integrated Pest Management to traditional farms, an experiment using these methods was designed to gather data specifically on costs affected. A schematic diagram explaining the flow of the experiment and comparison of the methods is shown in Figure 1.1.

The three methods are embedded in the regular production process from seeding to harvesting. Basically, different methods of pest protection were being compared. Nevertheless, the evaluation was kept at the level of whole farm operations including all of the farm costs in an effort to elucidate the response of profitability to fluctuations in the market price.

In traditional operations, spraying is done as part of a regular routine; the fields are treated regardless of the pest population present. On the other hand, conventional scouting and the sequential sampling methods, both under IPM, perform a deterministic action. Scouting is used to obtain information regarding the need to spray. Therefore the producer has the option of treating or not treating the field. This part is very crucial and would affect a significant portion of farm production. Since both methods are under IPM, the pest management processes as a

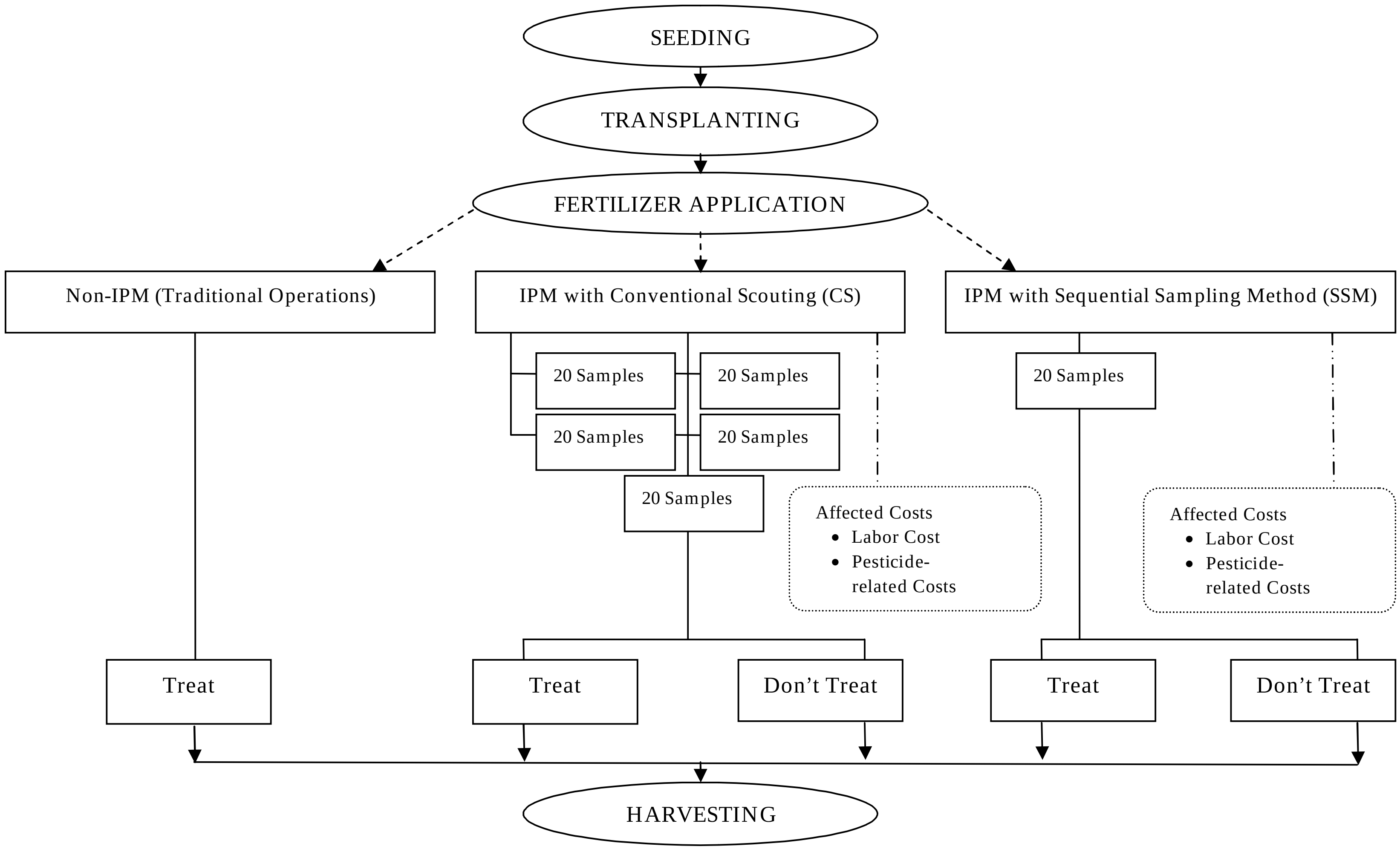

Figure 1.1 Schematic diagram of the difference in the three methods as a process in planting.

whole are similar except for the method of scouting used. A generalized production system with the number of samples required for each IPM method is shown in Figure 1.1.

The affected inputs account for a vital reduction of farm expenses thus the study analyzes it empirically. To achieve this, different economic and financial concepts were used. In an attempt to verify the corresponding percentage of savings to the 75 percent reduction in scouting inputs (samples and time), the research used costs and returns analysis. In conjunction with this analysis, production and cost in the short run were utilized to identify the break-even price (p^b) and shut-down price (p^s) for different scenarios. These relationships are shown in Figure 1.2. This process allows the examination of profit response paired with potential price changes.

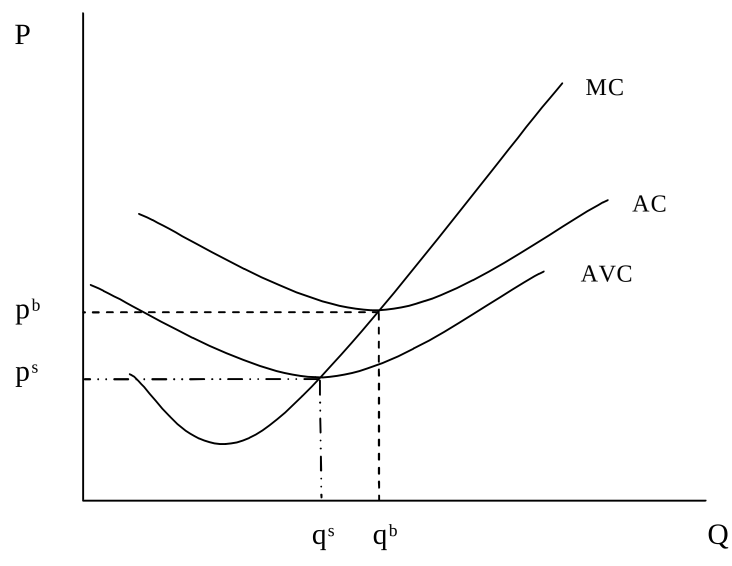

Figure 1.2 Graphical representation of production and costs relationships.

CHAPTER II

REVIEW OF RELATED LITERATURE

Why Collards?

Aside from the fact that collards is not a seasonal food for Thanksgiving or Christmas for people in the South anymore, South Carolina is one of the major states that produces collards in North America. Collard acreage in South Carolina grew from 1,840 acres in 1996-97, to 2,500 acres in 2000, and to about 3,800 acres recently (J. P. Smith, 2007). Moreover, the climate in central South Carolina is conducive for collard production allowing year-round production. Finally, the campaign 'Green Living' encouraging people to eat greens could drive collard demand higher, yet collard research is sparse. Previous studies were collective analyses of vegetables not focusing on a particular crop.

Pest Control Practices: A Deeper Look

Evidence of agriculture dates back to 8000 BC and pest control is at least as old as agriculture. There was a point in time where our primitive ancestors probably found that insects were more useful as food than they were troublesome pests as evidenced by primitive cultures eating lice from another person's hair. Not until the dawn of organized agriculture when insects attacked the plants we grew for food that we first recognized them as a potential threat to our own survival (Meyer 2003). Since then, humans have learned to protect crops from competing species of plants (weeds) along with herbivores (insect pests) competing with humans.

Use of sulfur compounds to control insects and mites, planting date manipulation (probably the origin of crop rotation), and use of mercury, arsenic and lead are some of the pest management practices known during the ancient period. Biological controls such as predatory animals, row cropping, weeding and cultivation, as well as burning, oil-sprays and rat-proof granaries were some other types of pest control performed thousands of years ago. Most of these strategies were embedded in religion or superstitions, a few had real scientific merit (Meyer 2003).

It was only with the industrialization and mechanization of agriculture in the 18th and 19th centuries, and the introduction of natural pesticides such as pyrethrum (from chrysanthemum), rotenone (from the roots of tropical vegetables), and derris that chemical pest control became the method of choice. Chemical use continuously became predominant. Different kinds of chemical controls were during this time. Resistance to some chemical pest control products developed in some pest species during the early 20th century.

Concepts of economic thresholds, economic levels and integrated control developed by V.M. Stern, R.F. Smith, R. van den Bosch and K.S. Hagen were introduced in 1959 due to the resistance shown by pests (Tvedten, 2001). In 1967, Smith and van den Bosch coined the term Integrated Pest Management (IPM) to encompass these concepts which was supported by L.R. Clark, P.W. Geier, R.D. Hughes and R.F. Morris by emphasizing the relevance of ecology to IPM through the concept of "Life Systems". The US National Academy of Sciences formalized the term Integrated Pest Management (IPM) in 1969 (Tvedten, 2001).

One year later, Dichloro-Diphenyl-Trichloroethane (DDT), a major synthetic pesticide discovered by Dr. Paul Muller during World War II was banned as a pesticide. It all started when the book *Silent Spring* by Rachel Carson, specified the environmental impacts of the indiscriminate spraying of pesticides, particularly DDT in the US further questioning the logic of releasing large amounts of chemicals into the environment without fully understanding their effects on ecology and human health. This is one of the key events in the birth of the environmental movement (Carson, 1962).

People became more conscious about health risks associated with toxic chemicals used for food production. Pesticide use regulation became one of the priorities of the federal government and has been a hot issue ever since. Chemical pest control is still the predominant type of pest control to date. Although it's long-term effects have led to a renewed interest in traditional and biological pest control towards the end of the 20th century. In fact, a lot of IPM-related success stories continue to grow and for farmers it is a good strategy for reducing dependence on chemical pesticides satisfying the ever changing preference of consumers.

Current Pest Management Programs

As defined by the United States Department of Agriculture (USDA), pest management includes a wide range of programs addressing human health, environmental, and economic issues related to the management of pest populations through a variety of science-based technologies. The goal is to provide safe, pest and disease-free homes, schools, parks, recreational areas, as well as a safe and affordable supply of blemish-free food products and a wholesome pesticide-free environment. The Cooperative State Research, Education and Extension Service (CSREES) funds programs and projects which support research, education, and extension activities that promote pest management in general, and reduced risk pest management in particular. Enumerated and discussed as follows are the four programs developed for pest management under the collaboration of the USDA, specifically CSREES with scientists in our nation's colleges and universities, other federal agencies and the private sector (USDA, 2007).

Bio-based Pest Management (BPM)

Bio-based management is the control of pests using one or more of five major tactics: 1) biological control--suppression of pests by using natural enemies (predators, parasites, competitors, and diseases), 2) microbial pesticides, 3) behavior-modifying chemicals, 4) genetic manipulation of pests, and 5) host plant resistance. The goal is to provide for safer and more effective methods of controlling pests while reducing our reliance on synthetic pesticides (USDA 2007). The primary goal of bio-intensive IPM is to provide guidelines and options for the effective management of pests and beneficial organisms in an ecological context. Its flexibility and environmental compatibility makes it useful in all types of cropping systems (Dufour, 2001).

Invasive Species (IS)

Invasive species are organisms that are non-native to an ecosystem and whose introduction causes economic, social, or environmental harm. Nearly every terrestrial, wetland, and aquatic ecosystem in the United States has been invaded by non-native species, with economic losses estimated at approximately $137 billion per year. The program is engaged in combat against invasive species by facilitating management plans of controlling their entry and population as well in a specific area. The USDA Animal and Plant Health Inspection Service–Plant Protection and Quarantine (APHIS-PPQ) is the best example where hand-carrying biological organisms and other germplasm were strictly prohibited from another country of origin to United States ports of entry without proper inspection and quarantine process by the APHIS-PPQ (USDA 2007).

Pesticides

Pesticide, as defined by the Environmental Protection Agency (EPA) is "any substance or mixture of substances intended for preventing, destroying, repelling, or lessening the damage of any pest." (USDA 2007) Pests are defined as any organism which has characteristics that are regarded as injurious or unwanted especially damaging to agriculture by feeding on crops or parasitizing livestock. A pesticide may be a chemical substance, biological agent (such as a virus or bacteria), antimicrobial, disinfectant or device used against pests including insects, plant pathogens, weeds, mollusks, birds, mammals, fish, nematodes (roundworms) and microbes that compete with humans for food, destroy property, spread or are a vector for disease or are a nuisance (USDA 2007).

For farmers, pesticides are frequently the tactic of choice for managing pests because of cost, effectiveness, availability, and convenience. It was evidenced by the 50-fold increase in its use since 1950. They have contributed impressively to our present-day agricultural productivity, giving way to farmers' high dependency on pesticides that led to calendar spraying. At the same time they have triggered issues and concerns such as pest resistance, water contamination, and worker exposure. Due to these reasons, development of botanical and bio-rational pesticides blossomed.

Integrated Pest Management (IPM)

Integrated Pest Management (IPM) is a decision support system for the selection and use of pest control tactics, singly or harmoniously coordinated into a management strategy, based on cost/benefit analyses that takes into account the interests of and impacts on producers, society and the environment (Kogan, 1998). This definition was proposed by Marcos Kogan and Waheed Bajwa in 2002 in their publication Compendium of IPM Definitions (CID) to reconcile the 67 definitions from the worldwide literature enclosed in their paper. They performed an analysis of the frequency of key words and expressions included in those definitions and presented it in a table which is shown in Table 2.1. Interestingly, 'Economics' appears to be the most frequently used term for the contextual meaning of IPM. It simply validates the significance of financial impact as a top priority of IPM aside from environmental protection. The last two terms, optimization/maximization and social or sociological were as well economic related and tackles costs and benefits for the producer and society. Other terms present in the table were expected to be used in defining IPM.

The emphasis of IPM is placed on anticipating and preventing pest problems whenever possible. It is a strategy that uses an array of complementary methods: natural predators and parasites, pest-resistant varieties, cultural practices, biological controls, various physical techniques and pesticide as the last resort which is only applied if the economic thresholds are exceeded and cannot be controlled by other means. This ecological approach can significantly reduce or eliminate the use of pesticides.

Integrated Pest Management can be viewed as an umbrella concept that can envelope the other pest management programs because it can use concepts from such programs depending on what is needed by the agricultural system. It is a very flexible and valuable tool when used as a concept to approach pest management. IPM is not a cookbook recipe for pest control, but an adaptable approach for dealing with agriculture's ever-changing financial, regulatory, and physical environment (Dufour, 2001).

Table 2.1 Frequency of occurrence of terms or expressions used in 67 definitions of IPM compiled in the Compendium of IPM Definitions.

Term or Expression	Referenced Context	Frequency (%)
Economics	Of the benefits to produce or users of the system	53.8
Environment	Benign effects of control measures in IPM. Factor in computation of benefits and costs of the IPM system beyond the producer level	48.1
Pest populations	Target for control tactics	40.4
Pest control	Goal of the IPM system	38.3
Methods or tactics	Components of the control actions	26.9
Ecology or ecological	The conceptual foundation of IPM or the system impacted by IPM tactics	25.0
System	Implementable program or ecological unit	24.2
Combination or multiple	Tactics or control methods	19.2
Economic threshold/ Economic injury level	Bases for decision making	17.3
Optimization/ Maximization	Benefits to producers, society, environment	13.5
Social/ Sociological	Factor in computation of benefits and costs of The IPM system beyond the producer level	9.6

Source: Kogan, Marcos and Bajwa, Waheed. Kogan, 2002. Compendium of IPM Definitions. Integrated Plant Protection Center (IPPC), Oregon State University, Corvallis.

Related Economic Analyses on IPM

During the mid-70's, economic analyses on pest management were already being conducted to determine if the system, even effective on pest control is also effective in terms of costs. Surprisingly, R. van den Bosch, V. Stern and L. A. Falcon pointed out a paradoxical result when they reevaluated the economic basis of *Lygus* (a bug species that was the key pest during those times) in California cotton. From an economic point of view, the lygus bugs treatments were costly yet the treated plots consistently had lower yields. That is, "it costs farmers money to lose money (Dufour, 2001)."

Several economic evaluations of IPM on cotton were performed and 18 of them showed that there is a decrease in production costs of 7 percent and an average decrease in pesticide use of 15 percent (Norton and Mullen, 1994). The IPM Continuum, with its goal of long term, sustainable, preventive, and avoidance strategies leaning to a more bio-intensive IPM as we go on would probably decrease chemical use and costs even further.

Govindasamy, Italia and Rabin in their article in 1998 titled *Consumer Response to IPM-Grown Produce* concluded that consumers indicated a strong support for IPM products through both high willingness-to-purchase and willingness-to-pay. However, they noted that before the average consumer exhibited the same level of interest in IPM as the sample in their study, some mechanism should be developed to educate the public about the IPM. This was agreed by Zehnder, Hope, Hill, Hoyle and Blake in their study in 2003 where they suggested that information on pest management practices provided at the market place could be used to provide a marketing advantage for IPM/organic produce. So, it is not only matters of making the farmers understand, but also an issue of making the consumers aware of, for IPM to work. Labeling “IPM Grown” produce is a key factor which is being practiced nowadays.

The study, according to Govindasamy, Italia and Rabin was performed to analyze the marketability or consumer response to IPM since nearly all of the relevant research related to IPM were supply or production oriented. Consumer response and attitudes, which is the other side of the market, would be valuable to producers if they are interested in venturing to a new product or system. For instance, an IPM product, as it is proven that existing market is an essential part in decision making. This way, farmers can evaluate if there is a market potential.

Results showed that consumers rank pesticide residue as their top food safety concern relative to other common sources of food risk. Nevertheless, high retail price is still a major obstacle in purchasing organic produce. In this light, results of two past studies are being reemphasized. First, IPM products are safer and often less expensive than conventional agriculture and more cost effective on a large scale than organic production (Govindasamy, Italia and Rabin, 1998). Second, the market for IPM produce may be as strong as for organic produce (with a difference of 7%) if consumers were provided information on IPM and could identify IPM produce at the point of sale (Zehnder, Hope, Hill, Hoyle and Blake, 2003). Thus, being cost effective and having strong market potential, IPM is where producers and consumers coincide. Wide adoption both by producers and consumers would force prices down. The low production cost coupled with consumers demand for IPM products will elicit producers to accept the practice. Considering IPM with newly developed scouting practices as a new technology in production, the market will experience the Treadmill Theory where producers generate short-term economic profits triggering wider adoption. Producers will seek newer technologies lowering costs making the supply function constantly shifting outward, pushing the equilibrium price downward assuming consumer demand doesn't change.

The IPM Continuum

The IPM Continuum is a collection of practices that are designed to maximize effectiveness and minimize risks associated with pests and pesticides (After, 1994). It has exactly the same sets of practices for IPM only with the emphasis on "establishing a long term, sustainable, preventive and avoidance strategies." As basically defined, it is the progression of pest management strategies towards least-risk, long-term prevention and avoidance of pests problems. The Continuum begins with a focus on monitoring and chemical suppression when pests approach unacceptable levels, and ends with balanced systems where pests remain at tolerable levels with minimal cultural and biological interventions (The IPM Institute of North America, Inc., 2004).

Pest Manager/ Ecosystem Manager

As others call them "ecosystem doctors", for he or she must pay close attention to the pulse of the managed ecosystem and stay abreast of developments in IPM and crop/pest biology and ecology, a pest manager is the most important link in a successful IPM program. Complete knowledge of the biology of the pest and the beneficial organisms associated with the pest, and understanding their interactions within the farm environment is his or her main job. The pest manager must know the weak links in the life cycle of pests when it is most susceptible to control measures and must incorporate this knowledge with tools and techniques of IPM to manage not one, but several pests. The approach is very simple: practice prevention, treat only when necessary and use the safest available alternative (least possible hazard to people, society and environment) to do the job (Buoniello, 2000).

Having a pest manager on site, however, entails additional farm costs. Since in-depth knowledge on biology is required, entomologists and other biology-related experts are more likely the most fitted individuals for the job. These individuals are degree-holders, therefore, demands higher salary for their work.

Pest Identification and Monitoring (Scouting)

Regular observation and proper pest identification are cornerstones of IPM. The effectiveness of pest management measures depends on correct identification since it is a vital component of decision making. Misidentification may be worse than useless; it may actually be harmful and cost time and money. Consultations with university personnel, private consultants and Cooperative Extension Service are of great help; books, pamphlets and websites are widely available also.

Inquiries like type of pest present, population, its life stages and beneficial insect population can be answered through monitoring and economic threshold and economic injury levels. Monitoring or scouting involves systematically checking crop fields for pests and beneficials, at regular intervals and at critical times, to gather information about the crop, pests and natural enemies (Dufour, 2001). Scouting should be balanced against its costs and frequency may vary with temperature, crop, growth phase of the crop, and pest populations.

Scouting practice is what's usually lacking in farms, or if they do, it is not done properly and religiously because it is very time consuming (Smith and Shepard, 2004). In response to this, different scouting methods have been developed for many crops. They differ by the number of samples obtained or the pattern of walking on the field. Some examples are the standard visual method (which is modified to sequential sampling), sticky trap method, windshield (estimate made from the edge of the field), whole-field (estimate based on walk through the field), range (weed densities rated on 1–5 scale at six locations in the field), counts (weeds estimated by counting at six locations in the field), rigid block method, the random walk method, and hot spot scouting. For the purposes of this study, the following methods were elaborated:

Conventional Sampling (CS)

The meaning of conventional sampling (CS) varies from farm to farm and location to location. It is basically the practice that the farm has been using for quite a long time. For this research, CS was defined as sampling using a fixed sample size of 100 collected from 100 different locations. This is the method that the selected farm at Lexington County, where the experiment was conducted considers to be standard. Besides, it is the sampling method that SSM is being compared to by Shepard and Smith. This type of sampling is also called conventional fixed-number scheme and is usually performed twice a week. All of the 100 samples should be collected from the whole farm which normally has a size of 10 acres or lower and is the maximum size of collard plantings in Lexington County.

Sequential Sampling Method (SSM)

Designed specifically for collards, this method is executed at least two times per week by sampling groups of five consecutive plants in a row instead of sampling five widely separated plants. A minimum of 20 samples per visit is needed as compared to CS requiring 100 samples. The suggested walking pattern is a “zig-zag” (see Figure 2.1) path through the field picking sampling sites near the edges in long narrow fields or sampling sites in the interior for square or irregularly-shaped fields (IPM for Cabbage and Collard, A Grower's Guide-Clemson Extension, 2005). A different walking pattern could be used, but make sure that all sections of the field are sampled. Like conventional sampling, the samples should come from the whole farm with the size of 10 acres or lower. Further research has to be done to validate the efficiency of the scouting design on plantings of larger sizes.

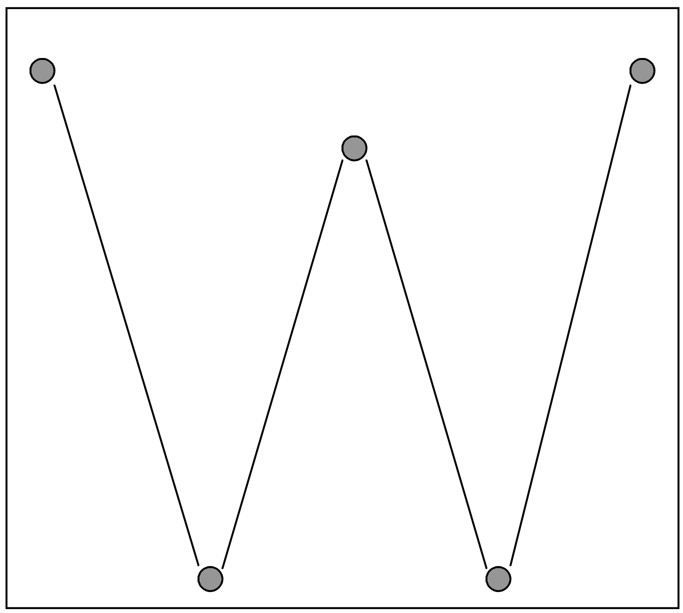

Figure 2.1 Suggested walking pattern for field sequential sampling

A customized sampling chart (Table 2.2) was designed for SSM to record the observations during scouting and to see if an application of insecticide is needed. Since the minimum number of plants needed to make a decision is 20 you only need to look for four groups of five preferably lying on each leg of the "W" walking pattern.

The guidelines on how to use the sheet are given in the IPM for Cabbage and Collard, A Grower's Guide-Clemson Extension, 2005. They are the following: 1) make a mark in the Damaged plants with larvae column each time you find a damaged plant with a caterpillar on it 2) keep the total number of damaged plants with caterpillars in the Cumulative total of damaged plants column. After the 20th sample, 3) compare your total number with the numbers shown in the Low Limit, Continue Sampling and High Limit columns to the right. If the total number is 0 or less than the number shown in the Low Limit column, you can stop sampling and you don't need to treat the field now. If the number is higher than the number shown in the High Limit column, you can stop sampling and treat the field. If the number is equal to or between the numbers shown in the Continue Sampling column, you will need to continue sampling until a decision is reached. If a decision hasn't been reached by the 45th sample, check again in two days.

Economically speaking, the possibility of arriving at a Continue Sampling column persistently has a tendency of giving higher costs instead of decreasing it. However, the creator of the scouting design who has been using the system for approximately 3-4 years confirmed that the occasion of getting a Continue Sampling decision is very rare and happens around once or twice a year (Smith – Personal Interview, 2007).

Table 2.2 Sampling Form for Insects of Cabbage and Collard

Field: _______________ Date: _______________

Sample No.	Damaged plants with larvae	Cumulative total of damaged plants	DON'T TREAT	Low Limit	Continue Sampling	High Limit	TREAT
1				X	X	X	
2				X	X	X	
3				X	X	X	
4				X	X	X	
5				X	X	X	
6				X	X	X	
7				X	X	X	
8				X	X	X	
9				X	X	X	
10				X	X	X	
11				X	X	X	
12				X	X	X	
13				X	X	X	
14				X	X	X	
15				X	X	X	
16				X	X	X	
17				X	X	X	
18				X	X	X	
19				X	X	X	
20				0	1-5	>5	
21				0	1-5	>5	
22				0	1-5	>5	
23				0	1-5	>5	
24				0	1-5	>5	
25				0	1-5	>5	
26				0	1-6	>6	
27				0	1-6	>6	
28				<2	2-6	>6	
29				<2	2-6	>6	
30				<2	2-6	>6	
31				<2	2-6	>6	
32				<2	2-7	>7	
33				<2	2-7	>7	
34				<2	2-7	>7	
35				<3	3-7	>7	
36				<3	3-7	>7	
37				<3	3-7	>7	
38				<3	3-7	>7	
39				<3	3-8	>8	
40				<3	3-8	>8	
41				<3	3-8	>8	
42				<4	4-8	>8	
43				<4	4-8	>8	
44				<4	4-8	>8	
45				<4	4-8	>8	

Economic Threshold and Economic Injury Levels

Economic threshold level (ETL), also known as economic action level is based on the concept that plants can tolerate a certain amount of some pests without causing economic loss. Therefore, if you scout a field and find pests below the established economic threshold, you do not have to spray. Remember, every time you spray, there is a cost involved; therefore, if the pest population is below the economic threshold, the cost to spray would be greater than the returns (IPM for Cabbage and Collard, A Grower's Guide-Clemson Extension, 2005). In short, it is the point at which suppression tactics should be applied in order to prevent pest populations from increasing to injurious levels.

Moreover, economic injury level (EIL) is the pest population that inflicts crop damage greater than the cost of control measures (Dufour, 2001). This is what we are avoiding thus we base our decisions on ETLs. Different crops have its unique ETL that should reflect the changing nature of the agricultural ecosystem for it is intimately related to the value of the crop and the part of the crop being attacked. Of course, pests attacking the fruit or the vegetable itself have much lower ETL than those pests attacking a non-saleable part of the plant.

Inherent Cost Issues on Beneficial Insects and Pest Resistance

Carl Huffaker once said “When we kill the natural enemies of pests, we inherit their work”. Beneficial insects are essential in pest management and killing them through careless pesticide use adds to the farm costs implicitly by taking over their ecological role. It comes in the form of increased effort to control pests since presence of natural enemies are deficient (Dufour, 2001).

Furthermore, the more frequent and higher rates of pesticides applied, the quicker the pest resistance develops. Pest resistance management is undertaken within the context of Integrated Pest Management Strategy. These are pesticide use according to economic thresholds and earliest possible detection of resistance in pest populations in order to limit chemical usage before efficiency decreases. Using alternatives, especially from a different chemical class or from a family of different mode of action pesticide is another way to combat resistance. However, the availability of pesticide products that can be used in rotation is reported to be decreasing (Bellinger, 1996). Basically, due to several regulatory actions to comply to, researchers and manufacturers lost the drive to develop new pesticides because costs of developing a pesticide are significant and discoveries might become unmarketable. Also, aside from difficulty in arguing with the requirements, costs for complying with the re-registration requirements for testing, and re-registration fees are having a heavy impact on the current and future availability of pesticides. Therefore, since development of new pesticides that can be used for rotation is diminishing due to cost related problems, support on slowing down the development of pest resistance by not exposing the pests with pesticides if superfluous is imperative.

IPM Products Certification

IPM raised crops or other ecology-based standards raised crops can undergo certification so that the public understands which crops are raised under low pesticide use. This will definitely give the farmers marketing advantage since most of the public is concerned about health and environmental safety nowadays. The certification program aside from having a goal of being a marketing vehicle to farmers aims to educate consumers about agriculture and the food system. This way, it may be an answer to the mechanisms necessary to be developed to educate the public about IPM. Also, it desires to keep all farmers moving along the "IPM Continuum." In order to get certified, farmers must have an 80 percent "score" on the IPM Program Elements within three years (Dufour, 2001).

Certified products bearing "ecolabels" are becoming more popular and dollars spent on eco-labeled foods are bound to grow appreciably as a result. The way eco-labeled programs deal with pesticide risk will emerge as a key factor in gaining consumer trust and brand loyalty, both of which are hard to establish and easily lost (Benbrook, 2002). In fact, there are over a dozen brands now such as the "NutriClean", "CORE Values Northeast" and the "Homegrown Wisconsin Potatoes". Eco-labeled products may have a more defined market and perhaps price premiums to help farmers offset any costs associated with implementing sustainable farming practices (Dufour, 2001). One possible disadvantage of such program is the additional paperwork, development of standards and guidelines and inspections required. In addition, it causes a threat regarding consumer confusion between “ecolabels” and “certified organic” labels which are absolutely different. In fact, food labeling programs fall into three broad categories namely--organic, residue claim-based and sustainable, or eco-friendly production systems--where each has its own “No Detectable Residues (NDR)” requirement.

Benefits of Pesticides

Of course pesticides aside from having negative effects are beneficial. Why do you think they are recommended to alleviate pests in the first place? Let us not take for granted the fact that pesticides help increase crop productivity and quality and are, therefore an indispensable tool for the sustainable production of high quality food and fibers. It enables farmers to grow more per unit area, with less tillage, reducing pressures on forests and other uncultivated land, conserving natural resources and reducing soil erosion. It is helping to improve the economics of farming and made farm work less arduous and labor intensive. It also helps to ensure that consumers have access to affordable food all year-round and help safeguard public health by controlling or eliminating pests that cause disease and property damage (Resistant Pest Management, Winter 1995). Remember that it is the way it was used why pesticides became harmful. Hence it is our responsibility to use them appropriately.

Limitations of the Study

The experimental design did not allow replication of the experiment thus the samples used only came from one set. The sample was limited because of time and resource constraints. This prohibited the analysis to make generalizations across several sampling means through hypothesis testing. Instead, the cost effectiveness was evaluated with the use of financial analysis methods and results of the study may only be relevant in one case or in one area.

CHAPTER III

METHODOLOGY

Scope and Area

The study analyzed the economic impact of shifting from Non-Integrated Pest Management (non-IPM) to IPM using conventional sampling to IPM using sequential scouting methods in a collard farm at Lexington County, South Carolina. Lexington County is ranked first among the 46 state counties and among the 3,078 U.S. counties in collard production (Census of Agriculture County Profile, 2002). A portion of one of the biggest collard farms was used for the experiment. Two parcels of land measuring 4 acres per parcel were planted with collards and the two different scouting methods were used on each. The experiment covered an entire cropping season of 16 weeks where data gathering for scouting-related activities began on September 17 and ended on October 30 of 2007.

Data Sources

Primary and secondary data were both utilized. Primary data were gathered from the field operations. Farm activities on scouting, specifically the number of labor hours spent, and bio-control or pesticide application were recorded. Materials and other farm inputs such as type and amount of pesticides used and related costs were also recorded. In addition, the amount of farm output, and other farm-related data were gathered.

Updated records on collards, costs and returns tables or enterprise budgets from the Clemson Extension Service, farm gate price of collards, interest, machinery and pesticide information were also used.

Analysis Methods

Tabular, Graphical and Descriptive Analysis

Descriptive analysis was used to explain the system of experiment which included the details of the process and assessment discussion between the operations of the farm systems being compared. Frequency of visits to the farm, hours spent on scouting, costs and returns and other relevant data were presented in tabular form to facilitate easier assessment of the figures.

Pie charts and bar graphs were also used for visual illustration. Reduction on time-spent on scouting and percentage shares of different costs of farm inputs in the budget of farms were explained and compared with the help of bar graphs and pie charts correspondingly.

Costs and Returns Analysis

The success of any crop farm depends upon its profitability. To study the cost-effectiveness of the two scouting methods with Integrated Pest

Management, profitability was analyzed using the costs and returns method. The estimated costs and returns per acre for the year 2006/2007 were obtained from the enterprise budgets of the Clemson Extension Service. The budget was primarily used for planning purposes only; thus IPM specific practices like scouting are not included in the assumptions. For the purpose of this analysis, the standard costs and returns per acre were used as the costs and returns per acre for non-IPM farms.

The same costs and returns per acre were divided into two different costs and returns per acre to incorporate the costs of practicing IPM with conventional scouting and IPM with sequential scouting. Other cost changes like the cost of pesticide (herbicide, insecticide and fungicide), tractor/machinery and others were also integrated.

Instead of looking at the net farm income, net income per box or profit per box and break-even price per box were given more attention in order to see the least necessary increase in price of collards in order to have higher profits while engaging to the scouting activity. Savings in costs were furthermore given interest.

Sensitivity Analysis on Profitability

After obtaining the break-even price and profit of the three farms, the price of the produce was adjusted by increasing and decreasing in increments of five percent. Profits at different price levels were then calculated to see how profit responds to changes in output price for the three scenarios. Incrementally decreasing the price along with the confirmed lower costs of production allows observing if the realized profits would be higher than the profit of traditional farms and helps identify if the CS and SSM systems can cater a higher amount of profit than Non-IPM produce at lower prices. On the other hand, output prices were increased because IPM products usually command 5 to 10 percent higher prices than regular products (Loureiro, McCluskey and Mittelhammer, 2002 and Anderson, Hollingsworth and Zee, 1996).

Percentage difference on the necessary changes in output price to command higher profit between farm without scouting and farm with conventional scouting (CS) and farm with sequential scouting method (SSM) were calculated and compared. To locate the minimum price that would yield the higher amount of profit than non-IPM produce, the break-even prices from different scenarios and the baseline profits were added. This number, plus a cent represented the minimum price that would yield higher profit than the non-IPM produce. The percent change in price relative to the price that gave the baseline profit was calculated and signify the minimum change in price necessary to attain a higher profit. Profitability potentials of CS and SSM relative to the non-IPM system and between CS and SSM systems were analyzed and discussed.

CHAPTER IV

RESULTS

Collards are one of the top 10 vegetable crops in most southeastern states and their production alone encompasses more than 5,000 acres in South Carolina (Farnham, Smith and Keinath 2004). With almost 50 percent of its farmland used for crops, Lexington County is the frontrunner of collard production both in the state as well as in the nation. This fact makes Lexington County the outstanding choice of location for the experiment. One of the major collard producing farms was selected and data were gathered. A series of economic analysis was performed and results are presented in the following sections.

The Farm and the Farmers

The selected farm is a fresh vegetable truck farm that specializes in the production of leafy greens --collard, mustard, turnip and kale-- green onion, herbs and radishes. It is a large-scale farm with products being shipped to any major city on the east coast.

Most of the workers in the farm are Hispanics. Apart from being knowledgeable on agriculture, it can be attributed to the growing population of Hispanics at Lexington County. In fact, there was an 84.3% growth in the population from 2000 to 2006 (U.S.

Census Bureau, Population Estimates, 2008) in Lexington County alone. The massive influx can be attributed to the need for economic opportunities coupled with the importance of social networks since most of the immigrants have relatives in the area and have their own small communities.

Part of being an immigrant and being surrounded by a Hispanic community, conveying how the experiment works to the farmer who performed the experiment became a hurdle. In spite of ascertaining that the farmer understands the mechanics of the experiment, there were still times that the farmer did not stop scouting after reaching the point where he could make a decision for sequential scouting method. These mistakes were corrected and adjusted accordingly since it was proven in Smith and Shepard's study that the sampling time relation is linear (Smith and Shepard 2004).

Non-IPM Farms

Non-IPM practicing farms carry out long-established operations especially when it comes to pesticide management. Over time, farmers subscribed to calendar spraying which protects the crop from pests, but at the same time imposes some negative externalities on the environment. Pesticides have become a substantial part of farm expenses and account for almost 10 percent of the total variable costs (Figure 4.1). Non-IPM farms do not perform any sort of needs assessment before spraying chemicals on the field.

It is noticeable that collard boxes and harvest and hauling have the largest shares of variable production expenses covering almost 50 percent of the variable costs. This is due to the fact that collards as a leafy vegetable are susceptible to bruises and other damages, therefore they require special handling techniques upon harvesting and storing.

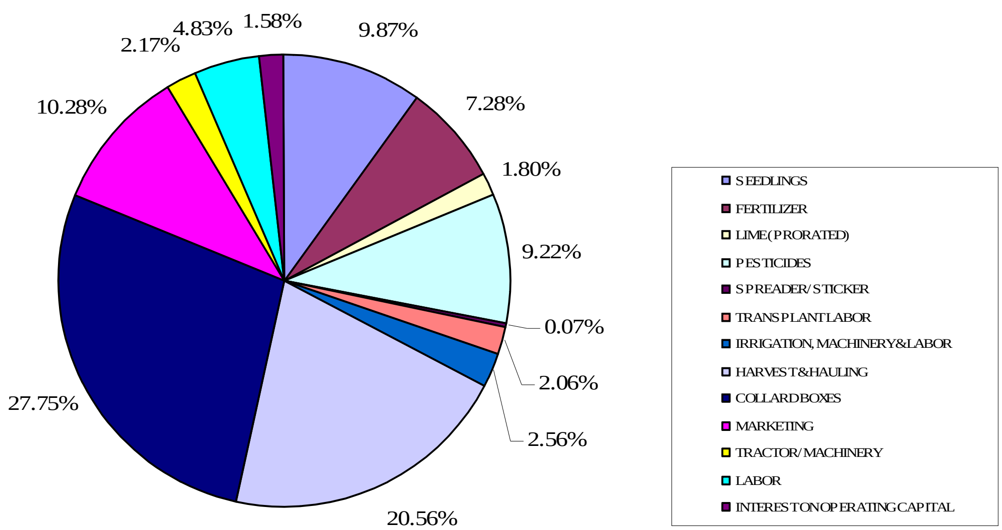

Figure 4.1. Percentage Share of Variable Inputs in Total Variable Cost

Since most of the operating farms carry out practices under non-IPM circumstances, the costs and returns for this farm was used as the basis of comparison for cost changes due to IPM with conventional practices and IPM with sequential sampling methods.

Conventional and Sequential Sampling Methods

Alternatively, the two other farm systems fall under Integrated Pest Management. Both IPM activities are conducted under proper pest management systems and only differ by the scouting method. Under conventional sampling, the scout needs to take 100 samples per visit before arriving at a conclusion whether to spray or not to spray pesticides while sequential sampling may require as few as 20 samples. In the experiment, the farmer scouted both fields nine times over the course of the harvesting season using corresponding treatments on each. The time spent per visit, decision achieved, and the reduction in time per acre from CS to SSM are illustrated in Table 4.1.

Table 4.1 Comparison of Scouting Time and Precision of Spraying Decision Between Conventional and Sequential Scouting Per Acre, Sept - Oct 2007

Visit	IPM-CS		IPM-SSM			Percent
	Time (hours)	Decision (Spray/Not)	Time (hours)	Decision (Spray/Not)	Time Difference	Reduction in Time
1	0.54	Spray	0.17	Spray	0.37	69
2	0.35	No	0.13	No	0.22	64
3	0.42	Spray	0.24	Spray	0.18	42
4	0.21	Spray	0.20	Spray	0.01	6
5	0.56	Spray	0.15	Spray	0.41	73
6	0.46	Spray	0.13	Spray	0.33	71
7	0.44	Spray	0.15	Spray	0.29	66
8	0.56	Spray	0.17	Spray	0.40	70
9	0.48	Spray	0.15	Spray	0.33	69
Total	4.01		1.48		2.53	
Mean	0.45		0.16		0.28	59

On average, it requires 0.45 hour or 27 minutes to get 100 samples and 0.16 hour or 9.6 minutes to obtain 20 samples per acre per visit for CS and SSM respectively. Both methods arrive at the same decision for every visit verifying the ability of the sequential scouting method to be precise with a fewer number of samples and scouting time.

Shifting from conventional scouting to sequential scouting showed a decrease in scouting time as shown in Table 4.1. Overall, there is a 59 percent reduction per visit. To have a better depiction, the time spent on scouting per visit was plotted using a bar graph (Figure 4.2).

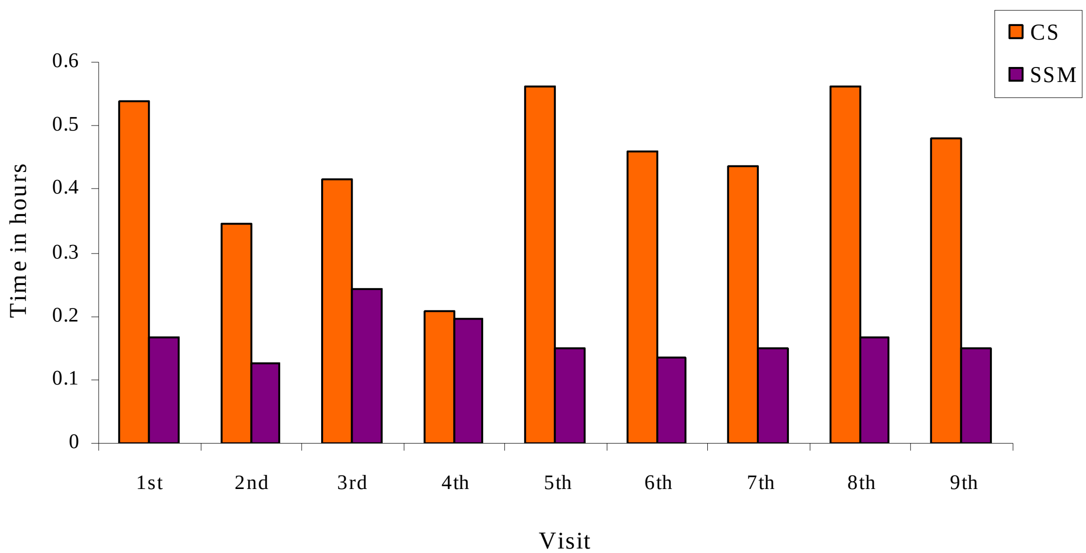

Figure 4.2 Time Spent on Scouting Per Visit, 2007

Figure 4.2 shows evidence that the reduction in time is more than 50 percent most of the time. However, this is not the case for the fourth visit. The time spent on scouting for CS and SSM for the fourth visit were almost the same (difference of only

6%). It is notable that the SSM time is close to the SSM average but the CS time deviated a lot from the average of CS times. This could be accounted to the fact that the person performing the scouting was not familiar with the new sequential scouting method and wasn't able to distinguish the two. Other possible causes that made this observation an outlier could be from the misreporting of data on the time sheet and improper execution of the method such as conducting and reporting SSM results under CS records.

Changes in Input Costs Attributable to Different Scouting Methods

Conventional Scouting

Table 4.2 illustrates the costs and returns per acre for a Non-Integrated Pest Management farm. It is the enterprise budget from the Clemson Extension Service for 2006/2007. The budget assumed that there were 600 boxes of collards that can be harvested per acre which can be sold at the price of $7.50 per box which yields a total return of $4,500.00 per acre. Moreover, the total variable cost amounts to $2,973.10 while the total cost was $3,501.47 per acre. These values give the break-even price per box for variable costs ($4.96 per box) and break-even price per box for total costs ($5.84 per box). The break-even prices were the "base prices" used in comparing the break-even prices calculated from other farm systems being analyzed. Detailed assumptions on per acre chemical use for collards and machinery and labor requirements can be seen in Tables 4.3. and 4.4 correspondingly.

Table 4.2 COLLARDS - IRRIGATED (HAND HARVEST)
ESTIMATED COSTS AND RETURNS PER ACRE, 2006/2007
600 BOXES - (20 LBS) HARVEST IN OCTOBER

	UNIT	QUANTITY	PRICE OR COST/UNIT	TOTAL PER ACRE
1. GROSS RECEIPTS				
COLLARDS***	BOX	600.00	$7.50	$4,500.00
TOTAL RECEIPTS:				$4,500.00
2. VARIABLE COSTS				
SEEDLINGS****	THOU.	16.00	$18.00	$288.00
FERTILIZER				
5-10-10 (SPREAD)	CWT	12.00	$11.38	$136.56
SIDE DRESSING-CALCIUM NITRATE	CWT	4.00	$19.00	$76.00
LIME (PRORATED)	TON	1.00	$52.50	$52.50
HERBICIDES	ACRE	1.00	$5.25	$5.25
INSECTICIDES	ACRE	1.00	$149.53	$149.53
FUNGICIDES	ACRE	1.00	$114.25	$114.25
SPREADER/STICKER	ACRE	1.00	$2.00	$2.00
TRANSPLANT LABOR	HRS	10.00	$6.00	$60.00
IRRIGATION, MACHINERY & LABOR	ACRE	1.00	$74.73	$74.73
HARVEST & HAULING	BOX	600.00	$1.00	$600.00
COLLARD BOXES	EACH	600.00	$1.35	$810.00
MARKETING	BOX	600.00	$0.50	$300.00
TRACTOR/MACHINERY	ACRE	1.00	$63.26	$63.26
LABOR	HRS	21.67	$9.00	$195.03
INTEREST ON OPERATING CAPITAL	DOL.	$511.04	9.0%	$45.99
TOTAL VARIABLE COSTS:				$2,973.10
3. INCOME ABOVE VARIABLE COSTS:				$1,526.90
4. FIXED COSTS				
TRACTOR/MACHINERY	ACRE	1.00	$99.00	$99.00
IRRIGATION	ACRE	1.00	$141.66	$141.66
TOTAL FIXED COSTS:				$240.66
5. OTHER COSTS				
LAND RENT	ACRE	1.00	$25.00	$25.00
GENERAL OVERHEAD	DOL.	$2,918.93	9.0%	$262.70
TOTAL OTHER COSTS:				$287.70
6. TOTAL COSTS:				$3,501.47
7. NET RETURNS TO RISK AND MANAGEMENT:				$998.53

BREAK-EVEN YIELD			*BREAK-EVEN PRICE PER BOX*	
VARIABLE COSTS	260	BOX	VARIABLE COSTS	$4.96
TOTAL COSTS	360	BOX	TOTAL COSTS	$5.84

*PLEASE NOTE: THIS BUDGET IS FOR PLANNING PURPOSES ONLY.
**BASED ON IMPROVED PRODUCTION PRACTICES FOR COMMERCIAL PRODUCERS.
***APPROXIMATELY EIGHTEEN PLANTS PER BOX. WEIGHT OF BOX IS 18-20 POUNDS.
****AVERAGE COST BASED ON FIELD GROWN AT LOWER-END OF $12
AND GREENHOUSE TRANSPLANT AT HIGHER-END OF $24.
Source: Clemson Extension Service - Enterprise Budgets, 2006/2007

Table 4.3 CHEMICAL USE ASSUMPTIONS FOR COLLARDS (NON-IPM FARMS)

	UNIT	QUANTITY	PRICE OR COST/UNIT	TOTAL PER ACRE	MONTH
HERBICIDES					
trifluralin (Treflan EC)	PT	1.50	$3.50	$5.25	1x JUL
INSECTICIDES					
spinosad (Spintor)	OZ	4.00	$4.57	$18.28	1x SEPT, 1x OCT
bacillus thuringiensis (Xentari)	LB	10.50	$12.50	$131.25	3x SEPT, 3x OCT 1x NOV
FUNGICIDES					
fosetyl-Al (Aliette)	LB	6.00	$11.50	$69.00	1x OCT, 1x NOV
azoxystrobin (Amistar)	OZ	4.00	$6.25	$25.00	1x SEPT
cupric hydroxide (Kocide)	LB	7.50	$2.70	$20.25	1x AUG, 1x SEP 1x OCT
TOTAL:				$269.03	

*The bacillus thuringiensis products should be the mainstay of caterpillar management program. Spintor, Proclaim, and Intrepid should be rotated to caterpillars not responding to the bacillus thuringiensis products.

The above listed chemicals are examples and do not imply exclusive recommendations by Clemson University. The "Vegetable Crop Guidelines for the Southeastern US" must be consulted. Production Assumptions provided by Powell Smith, (803) 284-3343,jpsmth@clemson.edu.

Source: Vegetable Enterprise Budgets for South Carolina2006/2007. Extension Economics Report EER 226, Clemson University Extension Service. October 2006

Table 4.4 PER ACRE MACHINERY AND LABOR REQUIREMENTS FOR COLLARDS (NON-IPM FARMS)

MONTH	OPERATION	TIMES OVER	LABOR HOURS	MACHINE HOURS	VARIABLE COSTS	FIXED COSTS
7	DISK W/ SPRAYER 16'	1.00	0.17	0.15	$2.00	$3.42
8	SUBSOILER-BEDDER 4-ROW	1.00	0.21	0.19	$3.05	$2.87
8	TRANSPLANTER 2-ROW	1.00	2.52	2.29	$13.74	$24.23
8&9	SIDEDRESSER 2-ROW	2.00	1.23	1.12	$9.04	$9.90
8,9,10&1 1	NURSE TANK ON PICK-UP	10.00	1.87	1.70	$10.50	$16.00
8,9&10	CULTIVATOR 4-ROW	3.00	0.76	0.69	$5.94	$7.11
8,9&10	PULL TYPE SPRAYER	9.00	1.78	1.62	$11.61	$24.39
10	TRUCK 1.5 TON	3.00	0.76	0.69	$4.32	$6.66
8&10	FARM WAGON	2.00	0.33	0.30	$3.06	$4.42
PER ACRE TOTALS FOR SELECTED OPERATIONS			9.63	8.75	$63.26	$99.00
UNALLOCATED LABOR (HRS. /AC.)			12.04			

Note: ten inches of water is applied using a 10 acre cable tow travel gun irrigation system. Two applications are put down in each month of August, September and October. It is assumed that the irrigation system is used on two crops each year. This results in reducing the fixed cost by 1/2. Approximately three plants per bunch. Six bunches per box. Weight of box is 18-20 pounds.

Source: Vegetable Enterprise Budgets for South Carolina2006/2007. Extension Economics Report EER 226, Clemson University Extension Service. October 2006

Most of the inputs specifically its costs, differ for an IPM farm using conventional scouting, its costs and returns per acre are shown in Table 4.5. The variable costs affected were pesticides (herbicide, fungicide and insecticide) and other pest protection costs, tractor/machinery, labor and interest on operating capital while general overhead costs changed for the fixed costs. In general, the total cost per acre of producing under IPM with CS was lower than Non-IPM farms.

Specifically, the herbicide, fungicide and insecticide costs were smaller due to less application of pesticides brought about by scouting. As seen on Table 4.1, one application was eliminated under IPM with CS. Pesticide application was less thus the amount of pesticides used also became smaller. Aside from this, different kinds and unit prices of pesticides affected the variation in costs. Farms using IPM with CS also used beneficial insects in place of other farm chemicals to protect the vegetables from damaging insects. Taken as a whole, the pesticide and pest related costs for the non-IPM farm was $269.03 per acre whereas for IPM with CS farm was $160.35 per acre which gives a 40 percent reduction in pesticide costs ($108.68/acre). The complete chemical use and other pest protection information for collards under IPM with CS are presented in Table 4.6.

The tractor/machinery expenses were also affected because of the reduction in the overall spraying time. Variable costs related to the pull-type

Table 4.5 COLLARDS - IRRIGATED (HAND HARVEST USING CONVENTIONAL SCOUTING)
ESTIMATED COSTS AND RETURNS PER ACRE, 2007
600 BOXES - (20 LBS) HARVEST IN OCTOBER)

	UNIT	QUANTITY	PRICE OR COST/UNIT	TOTAL PER ACRE
1. GROSS RECEIPTS				
COLLARDS***	BOX	600.00	$7.50	$4,500.00
TOTAL RECEIPTS:				$4,500.00
2. VARIABLE COSTS				
SEEDLINGS****	THOU.	16.00	$18.00	$288.00
FERTILIZER				
5-10-10 (SPREAD)	CWT	12.00	$11.38	$136.56
SIDE DRESSING-CALCIUM NITRATE	CWT	4.00	$19.00	$76.00
LIME (PRORATED)	TON	1.00	$52.50	$52.50
HERBICIDES	ACRE	1.00	$2.36	$2.36
INSECTICIDES	ACRE	1.00	$65.75	$65.75
FUNGICIDES	ACRE	1.00	$69.02	$69.02
BENEFICIAL INSECTS	ACRE	1.00	$23.22	$23.22
SPREADER/STICKER	ACRE	1.00	$2.00	$2.00
TRANSPLANT LABOR	HRS	10.00	$6.00	$60.00
IRRIGATION, MACHINERY & LABOR	ACRE	1.00	$74.73	$74.73
HARVEST & HAULING	BOX	600.00	$1.00	$600.00
COLLARD BOXES	EACH	600.00	$1.35	$810.00
MARKETING	BOX	600.00	$0.50	$300.00
TRACTOR/MACHINERY	ACRE	1.00	$61.97	$61.97
LABOR	HRS	25.48	$9.00	$229.32
INTEREST ON OPERATING CAPITAL	DOL.	$312.05	9.0%	$28.08
TOTAL VARIABLE COSTS:				$2,879.51
3. INCOME ABOVE VARIABLE COSTS:				$1,620.49
4. FIXED COSTS				
TRACTOR/MACHINERY	ACRE	1.00	$99.00	$99.00
IRRIGATION	ACRE	1.00	$141.66	$141.66
TOTAL FIXED COSTS:				$240.66
5. OTHER COSTS				
LAND RENT	ACRE	1.00	$25.00	$25.00
GENERAL OVERHEAD	DOL.	$2,879.51	9.0%	$259.16
TOTAL OTHER COSTS:				$284.16
6. TOTAL COSTS:				$3,404.33
7. NET RETURNS TO RISK AND MANAGEMENT:				$1,095.67

BREAK-EVEN YIELD			*BREAK-EVEN PRICE PER BOX*	
VARIABLE COSTS	260	BOX	VARIABLE COSTS	$4.80
TOTAL COSTS	360	BOX	TOTAL COSTS	$5.67

*PLEASE NOTE: THIS BUDGET IS FOR PLANNING PURPOSES ONLY.
**BASED ON IMPROVED PRODUCTION PRACTICES FOR COMMERCIAL PRODUCERS.
***APPROXIMATELY EIGHTEEN PLANTS PER BOX. WEIGHT OF BOX IS 18-20 POUNDS.
****AVERAGE COST BASED ON FIELD GROWN AT LOWER-END OF $12
AND GREENHOUSE TRANSPLANT AT HIGHER-END OF $24.
Source: Clemson Extension Service - Enterprise Budgets, 2006/2007

Table 4.6 CHEMICAL USE AND OTHER PEST PROTECTION ASSUMPTIONS FOR COLLARDS (IPM FARMS WITH CS AND SSM)

	UNIT	QUANTITY	PRICE OR COST/UNIT	TOTAL PER ACRE	MONTH
HERBICIDES					
trifluralin (Treflan EC)	PT.	1.00	$2.36	$2.36	1x SEPT
INSECTICIDES					
Proclaim	OZ	27.00	$1.24	$33.54	3x OCT
Rimon	OZ	10.00	$1.21	$12.11	1x SEPT
bacillus thuringiensis (Xentari)	LB	1.50	$13.40	$20.10	1x NOV
FUNGICIDES					
fosetyl-Al (Aliette)	LB	3.00	$12.08	$36.24	1x OCT
Prophyt	OZ	96.00	$0.34	$32.78	1x OCT, 1x NOV
BENEFICIAL INSECTS					
Cotesia Plutella	BAG	1.67	$9.50	$15.86	1x SEPT
		3.68	$2.00	$7.36	1x SEPT, 1x OCT
TOTAL:				$160.35	

*The bacillus thuringiensis products should be the mainstay of caterpillar management program. Spintor, Proclaim, and Intrepid should be rotated to caterpillars not responding to the bacillus thuringiensis products.

Table 4.7 PER ACRE MACHINERY AND LABOR REQUIREMENTS FOR COLLARDS (IPM FARMS WITH CS AND SSM)

MONTH	OPERATION	TIMES OVER	LABOR HOURS	MACHINE HOURS	VARIABLE COSTS	FIXED COSTS
7	DISK W/ SPRAYER 16'	1.00	0.17	0.15	$2.00	$3.42
8	SUBSOILER-BEDDER 4-ROW	1.00	0.21	0.19	$3.05	$2.87
8	TRANSPLANTER 2-ROW	1.00	2.52	2.29	$13.74	$24.23
8&9	SIDEDRESSER 2-ROW	2.00	1.23	1.12	$9.04	$9.90
8,9,10&11	NURSE TANK ON PICK-UP	10.00	1.87	1.70	$10.50	$16.00
8,9&10	CULTIVATOR 4-ROW	3.00	0.76	0.69	$5.94	$7.11
8,9&10	PULL TYPE SPRAYER	8.00	1.58	1.44	$10.32	$24.39
10	TRUCK 1.5 TON	3.00	0.76	0.69	$4.32	$6.66
8&10	FARM WAGON	2.00	0.33	0.30	$3.06	$4.42
PER ACRE TOTALS FOR SELECTED OPERATIONS			9.43	8.57	$61.97	$99.00
UNALLOCATED LABOR (HRS. /AC.)			12.04			

sprayer were reduced by one application corresponding to the one pesticide application reduction caused by scouting. Assumptions on per acre machinery and labor requirements for IPM with CS farms particularly the cost reduction of $1.29 per acre for the pull-type sprayer are elaborated in Table 4.7.

Labor cost is the most explicit expense affected by the scouting method. The change in labor cost was the net effect of additional hours spent on scouting and smaller labor hours used in spraying. A total of 4.01 scouting hours was added and 0.20 spraying hours was deducted from the quantity of labor used for non-IPM farms simultaneously. To maintain the *ceteris paribus* assumption and be consistent with the current situation, the wage per hour used for all of the systems is $9.00/hour per laborer. Overall, the added cost caused by labor was $34.29 per acre.

Both interest on operating capital and general overhead costs were affected by changes in the input costs discussed above. First, the interest on operating capital is dependent on some variable costs such as seeds, fertilizer and lime, pesticides, machinery repairs, fuel and other operating costs because it was assumed that all pre-harvest operation funds were borrowed from a credit source. In this case, since the pre-harvest operating cost was smaller in IPM with CS than non-IPM the interest on operating capital was also smaller. The interest rate assumed, similar to the rate used by the Clemson Extension Service was nine percent.

Second, the general overhead cost varies with total variable costs and given that the net effect of IPM with CS in the system showed a decrease in variable costs; the general overhead cost was also lower. This cost catches all other costs including utilities, telephone and emergencies. Similar to the assumptions of the Clemson Extension Service, the general overhead cost was assumed to be nine percent of the total variable costs.

Hence, the $17.91 and $8.42 disparity per acre between non-IPM and IPM with CS for interest on operating capital and general overhead costs respectively were indirect effects of the changes in pesticide, tractor/machinery and labor costs.

Sequential Scouting Method

Costs affected by performing the sequential scouting method under IPM were the same as the costs affected by using the IPM with conventional sampling techniques. Amounts of changes in the costs of herbicides, fungicides, insecticides, tractor/machinery and interest on operating capital were exactly alike except for labor and general overhead costs. This was anticipated because the sequential scouting method should be accurate with the conventional scouting results that influence the amount of pest protection-related inputs used in the shortest amount of time.

No additional cost representing the amount related to acquiring the know-how to perform the new sequential scouting method was given because the Clemson University Cooperative Extension Service does not charge anything for training the farmers. However in reality, given the language barrier, there might be a training cost to farmers or supervisors necessary.

Instead of adding 4.01 hours spent on scouting conventionally, only 1.48 hours of scouting was added to the labor cost under the sequential method. As a result, the expenditure on labor only increased by $11.52/acre instead of $34.29/acre under the IPM with CS system. In addition, since the total variable costs were smaller, the general overhead costs decreased to $257.11/acre, $2.05 less than the general overhead costs of IPM with CS. The costs and returns per acre of IPM with SSM farm are shown in Table 4.8. Details on chemical use, other pest protection information and per acre machinery and labor requirements were the same as that of the conventional sampling (Tables 4.6 and 4.7).

Comparison of the Net Impacts of CS and SSM Relative to Non-IPM Farms and Between CS and SSM System

After identifying all the input costs affected by performing IPM with CS and SSM in the farm, the overall financial impacts in terms of the amount of savings in costs per acre were summarized (Table 4.9). It can be seen that, there was a positive impact on shifting from non-IPM practices to IPM with scouting – both for conventional and

Table 4.8 COLLARDS - IRRIGATED (HAND HARVEST USING SEQUENTIAL SCOUTING)
ESTIMATED COSTS AND RETURNS PER ACRE, 2007
600 BOXES - (20 LBS) HARVEST IN OCTOBER)

	UNIT	QUANTITY	PRICE OR COST/UNIT	TOTAL PER ACRE
1. GROSS RECEIPTS				
COLLARDS***	BOX	600.00	$7.50	$4,500.00
TOTAL RECEIPTS:				$4,500.00
2. VARIABLE COSTS				
SEEDLINGS****	THOU.	16.00	$18.00	$288.00
FERTILIZER				
5-10-10 (SPREAD)	CWT	12.00	$11.38	$136.56
SIDE DRESSING-CALCIUM NITRATE	CWT	4.00	$19.00	$76.00
LIME (PRORATED)	TON	1.00	$52.50	$52.50
HERBICIDES	ACRE	1.00	$2.36	$2.36
INSECTICIDES	ACRE	1.00	$65.74	$65.74
FUNGICIDES	ACRE	1.00	$69.02	$69.02
BENEFICIAL INSECTS	ACRE	1.00	$23.22	$23.22
SPREADER/STICKER	ACRE	1.00	$2.00	$2.00
TRANSPLANT LABOR	HRS	10.00	$6.00	$60.00
IRRIGATION, MACHINERY & LABOR	ACRE	1.00	$74.73	$74.73
HARVEST & HAULING	BOX	600.00	$1.00	$600.00
COLLARD BOXES	EACH	600.00	$1.35	$810.00
MARKETING	BOX	600.00	$0.50	$300.00
TRACTOR/MACHINERY	ACRE	1.00	$61.97	$61.97
LABOR	HRS	22.95	$9.00	$206.55
INTEREST ON OPERATING CAPITAL	DOL.	$312.05	9.0%	$28.08
TOTAL VARIABLE COSTS:				$2,856.73
3. INCOME ABOVE VARIABLE COSTS:				$1,643.27
4. FIXED COSTS				
TRACTOR/MACHINERY	ACRE	1.00	$99.00	$99.00
IRRIGATION	ACRE	1.00	$141.66	$141.66
TOTAL FIXED COSTS:				$240.66
5. OTHER COSTS				
LAND RENT	ACRE	1.00	$25.00	$25.00
GENERAL OVERHEAD	DOL.	$2,856.73	9.0%	$257.11
TOTAL OTHER COSTS:				$282.11
6. TOTAL COSTS:				$3,379.50
7. NET RETURNS TO RISK AND MANAGEMENT:				$1,120.50

BREAK-EVEN YIELD			*BREAK-EVEN PRICE PER BOX*	
VARIABLE COSTS	260	BOX	VARIABLE COSTS	$4.76
TOTAL COSTS	360	BOX	TOTAL COSTS	$5.63

*PLEASE NOTE: THIS BUDGET IS FOR PLANNING PURPOSES ONLY.
**BASED ON IMPROVED PRODUCTION PRACTICES FOR COMMERCIAL PRODUCERS.
***APPROXIMATELY EIGHTEEN PLANTS PER BOX. WEIGHT OF BOX IS 18-20 POUNDS.
****AVERAGE COST BASED ON FIELD GROWN AT LOWER-END OF $12
AND GREENHOUSE TRANSPLANT AT HIGHER-END OF $24.
Source: Clemson Extension Service - Enterprise Budgets, 2006/2007

sequential methods. However, it is obvious that the farm under SSM experiences higher savings amounting to $126.83/acre (3.62 percent) compared to a savings of $102.01/acre (2.91 percent) for CS in total costs. The savings per acre for total variable costs of $116.36 (3.91 percent) for SSM and $93.59 (3.15 percent) for CS were consistent with the savings in total costs.

It has been seen that there are more savings in shifting from non-IPM to SSM than to CS and to strengthen this result, savings from IPM with CS to IPM with SSM were compared and the difference was calculated. Based on total costs, a farm could save $24.82/acre (0.73 percent) by using SSM rather than CS. The savings in total variable costs was $22.77/acre (0.79 percent). If the percentage changes were considered by themselves, the savings does not appear appealing because the percentages are minute. Yet, if taken as fraction of commercial production, these could account to significant dollar amounts.

The differences in savings between total costs and total variable costs for every system being compared were calculated and can be found in Table 4.9. It can be noted that the differences in savings were simply the differences in the general overhead costs of the systems in comparison. It was because the sole part of the fixed costs that changed for every system was the general overhead cost causing the variation in savings based on the type of cost. For instance, $8.42 was the difference in savings between total costs and total variable costs upon comparing non-IPM to the IPM with CS system and was also the difference between $267.58 and $259.16 which were the general overhead costs of non-IPM and IPM correspondingly.

Table 4.9 Per Acre Savings Between Different Systems by Type of Cost

	Non- IPM to IPM - CS		Non- IPM to IPM - SSM		CS to SSM	
	($/acre)	Percent (%)	($/acre)	Percent (%)	($/acre)	Percent (%)
Total Costs	102.01	2.91	126.83	3.62	24.82	0.73
Total Variable Costs	93.59	3.15	116.36	3.91	22.77	0.79
General Overhead Costs Savings	8.42	-	10.47	-	2.05	-

Whole Farm Effect and State-Level Savings

The quantified percentage savings for both methods under IPM seems to be trivial because the per acre figures are small. For this reason, the whole farm effect on savings was calculated to assess the impact on the grower. Using the average size of 10 acres or plantings for collards per farm in Lexington County and 5,000 acres of land planted with collards in South Carolina, the percentage savings were converted into per farm savings and total savings from collards at the state level (Table 4.10).

The per farm savings range from around $220 to $1,270 while the savings in South Carolina considering that 5,000 acres of land are planted with collards range from $114,000 to around $635,000 depending on the method being compared and the type of cost. These numbers provide sufficient evidence to say that the amount of savings derived were significant.

Table 4.10 Savings Between Different Systems by Type of Cost

	Non- IPM to IPM - CS			Non- IPM to IPM - SSM			CS to SSM		
	Percent (%)	($/farm)	($ savings for SC)	Percent (%)	($/farm)	($ savings for SC)	Percent (%)	($/farm)	($ savings for SC)
Total Costs	2.91	1,020	510,050	3.62	1,268	634,150	0.73	248	124,100
Total Variable Costs	3.15	936	467,950	3.91	1,164	581,800	0.79	228	113,850

IPM Product Certification Scenario

All of the impacts given above were under the assumption of no change in the output price. Such analysis was performed to see the financial impacts on the costs alone of conventional and sequential scouting to traditional farm operations *ceteris paribus*.

In this section, the possibilities of selling collards at higher prices as a result of practicing Integrated Pest Management were considered. This opportunity could only be accomplished upon subscribing to eco-labeling or environmental product certification which of course entails additional farm costs. There are many organizations and third parties that carry out certification procedures. Rate and annual fees vary depending on the program. For the purpose of the research, the individual farm fee of 0.5 percent of gross sales from the Food Alliance was used (*Food Alliance*, Standards Backgrounds Document, 2007). The annual fee, in terms of percentage of gross sales depends on a sliding scale (Table 4.11):

Table 4.11 Sliding Scale of Annual Certification Fee in Terms of Percentage of Gross Sales

Gross Sales	Percentage
First $175,000	0.5% or $400 whichever is greater
Next $125,000	0.25%
Additional Sales	0.10%

The 0.5 percent of gross sales annual certification fee was employed considering that the average collard plantings per farm in Lexington County is 10 acres (Census of Agriculture County Profile: Lexington, SC, 2002) and would have gross sales of $45,000

per farm if each one is planted with collards selling at $7.50/box. On a per acre basis, the cost of certification is $40.00, or $0.07 per box. The break-even price and price ranges for sales for all scenarios are summarized in Table 4.12. In the table break-even prices are given that cover total costs and total variable costs for each production system and for the IPM systems selling certified and non-certified products.

Table 4.12 Break-even Price Under Different Points of Production

		CS		SSM	
	Non-IPM ($/box)	No Certification Cost ($/box)	With Certification Cost ($/box)	No Certification Cost ($/box)	With Certification Cost ($/box)
TC	5.84	5.67	5.74	5.63	5.70
TVC	4.96	4.80	4.87	4.76	4.83

Sensitivity Analysis

Responses of profit on potential changes in prices were studied. The profit per box of collards grown under the non-Integrated Pest Management system were calculated and presented (Table 4.13) to be used as the basis for changes in profitability. Realized profits before and after the farm certification process at different price levels were obtained. These are the profits that were compared to the baseline profits from non-IPM system to see if the profit increased at a certain price level. Calculated prices and profits for IPM with CS are elaborated in Table 4.14.

Table 4.13 Baseline Profits (Non-IPM System)

	Sales Price ($/box)	Profit ($/box)
Based on TC	7.50	1.66
Based on TVC	7.50	2.54 *

* Also known as the returns above variable costs.

Table 4.14 Sensitivity Analysis on Profit - IPM with Conventional Scouting System

		Non-IPM Profit		Realized Profit Before Certification		Realized Profit After Certification	
Percent Changes in Price	Price ($/box)	Based on TC ($/box)	Based on TVC ($/box)	Based on TC ($/box)	Based on TVC ($/box)	Based on TC ($/box)	Based on TVC ($/box)
-20%	$6.00	$0.16	$1.04	$0.33	$1.20	$0.26	$1.13
-15%	$6.38	$0.54	$1.42	$0.71	$1.58	$0.64	$1.51
-10%	$6.75	$0.91	$1.79	$1.08	$1.95	$1.01	$1.88
-5%	$7.13	$1.29	$2.17	$1.46	$2.33	$1.39	$2.26
0%	$7.50	$1.66	$2.54	$1.83	$2.70	$1.76	$2.63
5%	$7.88	$2.04	$2.92	$2.21	$3.08	$2.14	$3.01
10%	$8.25	$2.41	$3.29	$2.58	$3.45	$2.51	$3.38
15%	$8.63	$2.79	$3.67	$2.96	$3.83	$2.89	$3.76
20%	$9.00	$3.16	$4.04	$3.33	$4.20	$3.26	$4.13

For the IPM with CS, at a sales price of $7.50/box which is basically the no change in price scenario, it is evident that the profits before and after certification were higher than the baseline profit of $1.66/box and $2.54/box for total costs and total variable costs, respectively. Accordingly, the profits before and after certification were all higher than the non-IPM farm profit at all price levels. These results proved that the farm's profitability was improved under the IPM with CS system.

It can be observed that realized profits at all price levels were higher before the certification process. These were caused by the additional fee for certification. However, noting that certified products can be sold at higher prices (5 to 10 percent), the probability of higher profits is larger. For instance, a box of CS-produced uncertified collards commands a net profit of $1.83 based on total cost, but could demand a $2.14 net profit if it were sold for the 5 percent higher IPM certified price.

Table 4.15 Sensitivity Analysis on Profit - IPM with Sequential Scouting System

		Non-IPM Profit		Realized Profit Before Certification		Realized Profit After Certification	
Percent Changes in Price	Price ($/box)	Based on TC ($/box)	Based on TVC ($/box)	Based on TC ($/box)	Based on TVC ($/box)	Based on TC ($/box)	Based on TVC ($/box)
-20%	$6.00	$0.16	$1.04	$0.37	$1.24	$0.30	$1.17
-15%	$6.38	$0.54	$1.42	$0.75	$1.62	$0.68	$1.55
-10%	$6.75	$0.91	$1.79	$1.12	$1.99	$1.05	$1.92
-5%	$7.13	$1.29	$2.17	$1.50	$2.37	$1.43	$2.30
0%	$7.50	$1.66	$2.54	$1.87	$2.74	$1.80	$2.67
5%	$7.88	$2.04	$2.92	$2.25	$3.12	$2.18	$3.05
10%	$8.25	$2.41	$3.29	$2.62	$3.49	$2.55	$3.42
15%	$8.63	$2.79	$3.67	$3.00	$3.87	$2.93	$3.80
20%	$9.00	$3.16	$4.04	$3.37	$4.24	$3.30	$4.17

Table 4.15 illustrates the calculated prices and profits for IPM with SSM. Same as for IPM with CS, the profits before and after certification were all higher than the non-IPM farm profit at all price levels. Thus IPM with SSM was confirmed to improve profitability as well. Similar to the IPM with CS system, the realized profits at all price levels were higher before than after certification for the same reason that is the additional certification cost.

Yet looking closely at the figures, it can be noted that the profits from IPM with SSM are higher than the profits from IPM with CS at all price levels both before and after certification. The $2.14 profit per box under IPM with CS could be stretched to $2.18/box under IPM with SSM. Thus, in terms of financial benefits among the three systems in comparison, production under IPM with SSM is better than the other systems. IPM with SSM is the optimal choice for profit maximization.

The least prices needed by the CS and SSM systems that can yield a higher profit and the corresponding percent changes relative to the sales price of traditional farms are listed in Table 4.16. Note that all of the minimum prices are lower than $7.50/box. It proves that CS and SSM systems can generate a higher profit than Non-IPM produce at lower prices. More importantly, the necessary percent changes for the minimum prices are mostly negative. SSM-After Certification and Both CS-Before and After Certification can accommodate a 2 percent decrease in sales price and still generate a higher profit. On the other hand, SSM-Before Certification can contain up to 3 percent decrease in sales price and is the most robust of all scenarios.

Table 4.16 Minimum Price and Percent Changes Necessary to Cover Additional Cost Due to Certification

			Minimum Price to have higher Profit	Minimum Change in Percent
CS	Before Certification	Break-even	$7.33	-0.02
		Shut-down	$7.34	-0.02
	After Certification	Break-even	$7.37	-0.02
		Shut-down	$7.38	-0.02
SSM	Before Certification	Break-even	$7.29	-0.03
		Shut-down	$7.30	-0.03
	After Certification	Break-even	$7.33	-0.02
		Shut-down	$7.34	-0.02

CHAPTER V

SUMMARY AND CONCLUSIONS

Three pest protection methods were compared in this study. Since pesticide spraying has been the common practice for decades, it was considered as the traditional operation and used as the baseline method for comparison. The other two methods fall under the Integrated Pest Management and only differ with method of scouting being used. These are IPM with conventional scouting which requires 100 samples at 100 different locations and IPM with sequential sampling method which only call for 20 samples collected from 5 different locations.

With the goal of assessing the cost-effectiveness of the two pest protection methods under IPM compared to traditional operations, experiments were performed and necessary economic and financial evaluation were undertaken. Results confirm that IPM with CS and IPM with SSM are both cost-effective and provide savings to the farm. Particularly, the cost savings generated from IPM with SSM (3.62 percent from total cost and 3.91 percent from total variable cost) is higher than the cost savings from IPM with CS (2.91 percent from total cost and 3.15 percent from total variable cost). The difference in cost savings between IPM with CS and IPM with SSM basically came from less scouting time of SSM thus lower labor cost for the farm.

Furthermore, aside from cost savings, IPM products can be sold at 5 to 10 percent higher than regular or uncertified products. Even though certification involves a fee, the benefit gained from it outweighs the cost. Hence, strong evidence attests suggests that production with IPM methods not only meets the environmental but more importantly the economical and social goals of sustainable agriculture.

More importantly, since markets and prices are volatile, negative shocks on sales price was analyzed. This was performed despite the fact that IPM produce demands higher prices to see the capability of the suggested methods to accommodate possible negative price changes. Both methods under all scenarios analyzed are able to sustain decrease in sales price 2 percent greater than conventional systems. This is a robust characteristic and only adds to the quality of the two methods.

Matching up IPM with CS and IPM with SSM, the later was proven to be more cost-effective. It can save 0.73 percent more than IPM with CS proportionate to total costs and 0.79 percent more with total variable costs. If the option for maximum profit is most wanted, using the sequential sampling method is the better alternative.

The savings in percent seems to be unimportant because the numbers are small but the savings are significant especially for commercial farms. This was shown by calculating the cost savings per farm and in the aggregate for the state.

After performing this economic analysis, the conclusion suggests that IPM with conventional sampling and IPM with sequential sampling are both improvements over conventional systems thus having positive impacts not only environmentally but also economically. Both methods are worthwhile tools while in transition to organic farming. However, for potentials on maximum profits, IPM with SSM is the superior choice.

Recommendations

Results of this study show a positive financial impact of IPM with conventional and IPM with sequential sampling when compared to traditional farms. These findings could be used in advancing the wide adoption of these methods, especially the IPM with SSM. Because farming is also a business, significant cost savings give the extra incentive, apart from environmental reasons, that should justify adoption of the SSM method.

In addition, since this research shows that SSM is financially efficient and environmentally beneficial, new systems analogous to the sequential scouting method applicable to other crops should be developed. Moreover, with the limitations of the study, the experiment could be conducted with an experimental design that allows repetition of methods in order to allow a more rigorous statistical analysis and generalization. Further, it is recommended to repeat the study in other locations for results verification and to diagnose necessary adjustments in order to ensure that the method is generally applicable.

For the purpose of future research, a regional impact analysis on the results of this study could be performed. The state level costs savings were measured in this paper but the analysis on this topic may be extended and given more detail. A more thorough county-level or state-level evaluation could be made. Aside from financial analysis, regional impact of the adoption of IPM with SSM on employment and effects on other sectors of industry could also be deliberated.

Lastly, a long-run analysis on the outlook towards prospective shift to organic farming is also a good subject matter to work on. Performing an analysis similar to this study to see the impact of shifting to organic farming from traditional operations or from IPM practices is suggested.

REFERENCES

After Balling, S., *The IPM Continuum-- In Constraints to the Adoption of Integrated Pest Management*, 1994. A. Sorenson, ed. National Foundation for IPM Education; and Benbrook, et al., 1996. Pest Management at the Crossroads. Consumers Union, Yonkers NY.

Anderson, M.D., Hollingsworth, C.S., Van Zee, V., Coli, W.M., and Rhodes, M., *Consumer Response to Integrated Pest Management and certification*. 1996. Integrated Pest Management Program, University of Massachusetts Extension, Amherst, MA 01003, USA

Bellinger R.G., *Pest Resistance to Pesticides.* March 1996. Department of Entomology, Clemson University.

Benbrook C.M., *Why Pesticides Risks Matter and pose Tough Challenges for Eco-label Programs (Session I).* 2002. Tuft's Eco-label Conference Paper. <http://nutrition.tufts.edu/pdf/conferences/ecolabels/Benbrook.pdf >

Buoniello R., *Talking About Pesticides with Your Customers: A Guide for the Pest Manager.* BCERF Environmental Health Educator. August 200. <http://envirocancer.cornell.edu/Factsheet/pesticide/fs35.talking.cfm >

Carson, Rachel., *Silent Spring.* 1962. Houghton Mifflin/Riverside Press

Clemson Extension: Department of Applied Economics and Statistics., *Collards – Irrigated (Hand Harvest): Estimated Costs and Returns Per Acre, 2006/2007.*

Clemson University IPM Program. 2007. <http://www.clemson.edu/scg/ipm/ >

Dufour R., *Bio-intensive Integrated Pest Management (IPM): Fundamentals of Sustainable Agriculture.* July 2001. A publication by Appropriate Technology Transfer for Rural Areas (ATTRA) Project operated by the National Center for Appropriate Technology under a grant from the Rural Business—Cooperative Service, U.S. Department of Agriculture.

Farnham, M.W., *Vegetable Crucifers – Status Report* . 2004. USDA Crucifer Crop Germplasm Committee and Committee Chair.

Food Alliance, *Fees for Farm and Ranch Certification*. 2007. <http://www.foodalliance.org/certification/farms_ranchers/farm-ranch-certification-fee-schedule>

Francis R.L., Smith J.P. and Shepard B.M. *Integrated Pest Management for Cabbage and Collard: A Grower's Guide*. 2005.

Govindasamy R., Italia J., Rabin J., *Consumer Response and Perceptions of Integrated Pest Management Produce*. May 1998. New Jersey Agricultural Experiment Station P-02137-5-98

Kogan, Marcos., *Integrated Pest Management: Historical Perspectives and Contemporary Developments*. 1998. Annual Reviews Incorporated. Entomology. Integrated Plant Protection Center, Oregon State Univesrity. Corvallis, Oregon.

Kogan M. and Bajwa W.I, *Compendium of IPM Definitions (CID): What is IPM and how is it defined in the Worldwide Literature?* 2002. Publication No. 998, Integrated Plant Protection Center (IPPC), Oregon State University, Corvallis.

Loureiro, M., McCluskey, J. and Mittelhammer, R., *Will Consumers Pay a Premium for Eco-labeled Apples?* 2002. The Journal of Consumer Affairs. Volume 36, No. 2. pp 203 – 219.

Meyer J.R., *Chapter 19: Pest Control Tactics*. 2003. General Entomology Notes on Management and Control. <http://www.cals.ncsu.edu/course/ent425/text19/tactics1.html >

Norton, G.W. and J. Mullen. *Economic Evaluation of Integrated Pest Management Programs: A Literature Review*. 1994. Virginia Cooperative Extension Publication 448-120. 112 p.

Resistant Pest Management. *A Biannual Newsletter of the Pesticide Research Center (PRC) in cooperation with the Insecticide Resistance Action Committee (IRAC), the Western Regional Coordinating Committee (WRCC-60) and the International Organization for Pest Resistant Management (IOPRM)*. Vol. 7, No. 2; Winter 1995.

Smith J.P., *A Field Level Example of IPM Adoption*. 2007.

Smith J.P. and Shepard B.M., *A Binomial Sequential Sampling Plan Using a Composite Threshold for Caterpillar Management in Fresh Market Collard*. 2004. Journal of Agricultural Urban Entomology. Vol. 21, No. 3 (2004). pp. 171-184

The IPM Institute of North America, Inc., 2004. <http://www.ipminstitute.org/school_standards_appendices.htm >

Tvedten, Stephen., *History of Pest Management*. 2001. A Mailing List for Continuing Information on Pesticides. <http://www.safe2use.com/ca-ipm/01-04-27.htm >

United States Department of Agriculture: Cooperative State Research, Education and Extension Service. 2007. <http://www.csrees.usda.gov/nea/pest/pest.html >

Zehnder G., Hope C., Hill H., Hoyle L. and Blake J., *An Assessment of Consumer Preferences for IPM-and Organically Grown Produce*. April 2003. Journal of Extension, Vol. 41 No. 2.

2002 Census of Agriculture County Profile: Lexington County, South Carolina., 2002. Fact Finders for Agriculture by NASS.