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# An economic analysis of cover crops in corn-dominated production systems

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# AN ECONOMIC ANALYSIS OF COVER CROPS IN CORN-DOMINATED PRODUCTION SYSTEMS

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# ABSTRACT

A survey data by Singer *et al.* (2007) was used to study the factors affecting the adoption of cover crops by the producers at the Corn Belt area of the United States. Data was collected from four states: Illinois, Indiana, Iowa, and Minnesota. Two binomial logit models were used for the econometric analysis. The first logit model was used to observe the factors affecting the adoption of cover crops by the producers. The second logit model was used to analyze the factors affecting the adoption of cover crops by producers in recent years, specifically, in past five years. The result of the study suggested that access to proper information about use and management of cover crops has positive and significant effect on adoption of cover crops. The results also suggest that producers who grow small grains like wheat and oats and producers who grow both crops and livestock are more likely to use cover crops. In recent periods, i.e., the past five years, the results suggest that number of acres farmed have a positive and significant effect on the adoption of cover crops. Also, in recent years, university extension programs did not have significant effect on the adoption of cover crops in the Corn Belt region of the United States.

**CHAPTER 1**

**INTRODUCTION**

This study examines the factors associated with the adoption of cover crops in farming systems in the Corn-Belt region of the central United States. Cover crops are crops grown to provide soil cover between the growing seasons to protect soil.

Besides providing soil cover, cover crops play other important roles, such as reducing soil erosion, increasing water infiltration, increasing nitrogen fixation, reducing soil compaction, suppressing weeds, and much more (Luna 1988; Peet 1996) . A single cover crop may not provide all of these benefits, but some cover crops might have more than one of the benefits listed (Luna, 1988).

The literature shows that cover crops have been used in agriculture for centuries because they help improve soil quality, reduce nitrogen leaching, and repel pests (Sundermeier, 1999). Though the use of cover crops was prevalent, modern agriculture has left it behind due to abundance and widespread use of fertilizers. As fertilizers became comparatively cheap, easily available, yielded desired results in a very short time, and were very easy to use, cover crops, along with other technologies, have been sidelined (Sundermeier, 1999). Increasing fertilizer use has increased their negative effects on the environment. With the increasing problem of soil erosion, creation of a "dead-zone" in the Gulf of Mexico due in part to nitrogen fertilizer from agricultural production in the Corn-Belt (USEPA, 2007), and increasing cost of fertilizers, among other reasons, the importance of the use of cover crops has been realized. Because much of the knowledge about cover crop management has been lost and due to the lack of experience of successfully incorporating cover crops in the cropping system, producers who may have wanted to use cover crops in their cropping systems have been reluctant to do so. Researchers have started to look into the use of cover crops in the cropping system, other benefits of cover

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crops, and different ways of incorporating cover crops in the cropping system to get more benefit out of their use.

Observing the overall history of cover crops, fertilizer use, effect of fertilizers, and the agri-environmental situation, the use of cover crops in cropping systems is very beneficial as they help reduce nutrient leaching from the soil and control soil erosion. Understanding the factors that affect the use of cover crops by producers will help us to understand potential barriers for the adoption of cover crops by producers. This will help producers, resource conservation personnel, and policy makers to work together to develop alternatives that will help to increase the use of cover crops in cropping systems. This research will help shed some light on some of these key factors facilitating or hindering cover crop adoption.

## 1.1. Introduction to Cover Crops

Cover crops include any crop grown to provide soil cover before or in between cash crops. They could be any annual, biennial, or perennial plant (Sullivan, 2003). The most common cover crops are annual cover crops, but on some farms, where nothing is grown for multiple years, some perennial cover crops are grown. Cover crops are generally not harvested but are plowed into the soil so that they will act as green manure, or provide nitrogen to the soil (Sullivan, 2003). Depending on soil types, weather conditions, and type of cash crop, single or multiple cover crops are grown together. Cover crops can be included in a production cycle as a cash crop in a rotation, as a companion crop or living mulch between the rows of the cash crop, as a "catch" crop planted between the rows of cash crop to reduce leaching of nutrients, or even as an off-season crop grown to protect soil (Peet, 1996). Cover crops can be leguminous, like vetch and clover, which add nitrogen to the soil, or non-leguminous, like wheat and ryegrass, which control erosion (Fageria *et al.*, 2005). Non-leguminous cover crops such as cereal rye and annual ryegrass are capable of reducing nitrogen leaching during wet seasons (Kuo, 1998).

Legume cover crops provide a substantial amount of biologically fixed nitrogen (N) to the primary crop, as well as provide other advantages offered by a non-leguminous cover crop (Frye *et al.*, 1988). The choice of cover crops depends on the objectives of the producer for the farm land and regarding cost-benefit, environmental effects, and time management related to cover crop use.

## 1.2. Advantages of Cover Crops

Cover crops can be included in the cropping system for various reasons. Cover crops have different properties which can be chosen according to the needs of the producer, such as to improve soil fertility, to enhance soil structure, to help in pest or disease management, or to improve environmental quality.

One of the major benefits of cover crops is to protect soil from wind and water erosion (Dabney *et al.*, 2001). Soil crust forms when permeable soil is exposed to raindrops, which reduces the water infiltration rate in soil, thus increasing runoff (Morin *et al.*, 1981). Cover crops help to reduce crusting of the soil surface by increasing soil organic matter, which improves soil water infiltration and holding capacity (Fageria *et al.*, 2005). The reduction of soil erosion increases even more when cover crops are combined with some conservation tillage practices (Hartwig, 1988).

Cover crops help add organic matter to the soil, which is often lost during cultivation of cash crop for harvest. During the breakdown of organic matter by microorganisms, some compounds like gums and resins are formed that are resistant to decomposition. These compounds bind together with soil particles which make soil easy to till with high water infiltration capacity. Cover crops are either left to decompose on and in the soil or killed before growing a cash crop. In both cases, cover crops provide organic matter to the soil, which ultimately helps improve soil quality.

Cover crops and green manure crops can reduce the need for synthetic fertilizers, and even eliminate the need for herbicides in certain situations. According to Luna (1988), producers prefer to use legume cover crops such as clovers, vetch, and Austrian field pea because they can biologically fix nitrogen through a symbiotic relationship with *Rhizobia* bacteria living in the nodules on their roots. From 38 to 214 pounds of nitrogen per acre can accumulate in the soil with legume cover crops, compared to non-legume cover crops. The use of these cover crops can greatly reduce or even replace the need for manufactured nitrogen fertilizer (Luna, 1988). This property of legume cover crops also reduces nitrogen leaching into surface and ground water.

The basic benefit of cover crop, ground cover, also contributes to the maintenance of soil moisture. Cover crop residue left on the soil improves infiltration of the rain water and also reduces water loss due to evaporation. Channels formed by decayed roots and enhanced earthworm activity are principal factors responsible for the increase in water infiltration capacity (Lal *et al.*, 1991)

The problem of weeds has been a major issue, especially with no-till crop production. With the proper choice and management of cover crops and plant residues, it may be possible to help herbicides work better, if not reduce the number and amount of herbicides used in a no-till cropping system (Worsham, 1991). This might be possible because while growing, cover crops compete with the weeds, and this might reduce the growth of weeds or make it difficult to grow properly as it would have done without cover crops.

**1.3. Limitations of Cover Crops**

Most of the benefits of cover crops discussed in the previous section come with opportunity cost, extra labor cost, extra seed cost, time management cost, and so on. Using cover crops in a cropping system requires more expenditure compared to a cropping system without cover crops. The extra costs associated with cover crops include expenses for cover crop seed

and labor costs to plant, maintain and kill the cover crop. Most of the benefits of using cover crops may not be observed in the current year. So if evaluated right after cover crops are used in the cropping system, it might not prove to be economically beneficial for producers to incorporate cover crops into the cropping system.

Water consumption by cover crops might be a major problem of using cover crops in the areas with limited water availability for the cash crops. Though cover crops help to maintain soil moisture, cover crops need some moisture to grow. In some cases, the moisture that cover crops use might be the only moisture available for the cash crops. In cases like this, incorporating cover crops might be detrimental rather than advantageous.

Incorporating cover crops in the cropping system requires good farm management skills. It requires proper time management which includes choosing a good growing time and killing time for a particular cover crop, and selecting the best cover crop for the field. It also requires management skill to handle extra cost for the labor and cover crop seed. If not managed properly, including a cover crop in the system might be very costly and not beneficial. Each cover crop has a particular time of the year for which it is best suited, so in the first few years of using cover crops, producers might have to change their crop rotations.

Pest control might be an advantage of using cover crops, but at the same time, some pests attracted to or associated with cover crops might be a disadvantage to certain cash crops. Some pests which might be harmful to the cash crop may find shelter in cover crops. This will not help to manage pests but may make a favorable place for pests to survive and, hence, negatively impact the growth of the cash crop.

## 1.4. Problem Statement and Motivation

Despite many advantages of cover crops, most producers do not use them in their farming operations. Without better understanding the factors associated with the use of cover crops, step

taken to increase their use may not be very effective. Understanding the factors that influence producers' decisions to use or not to use cover crops can help extension and resource conservation personnel to design programs that encourage the use of cover crops in the future. Reviewing the previous literature indicates that limited research has been done to examine the factors associated with the adoption or use of cover crops. Almost all of the previous literature related to cover crops has identified many benefits, but most researchers have concluded that cover crops are not economically beneficial for producers (Mallory, 1998).

## 1.5. Objectives

This study aims to determine the effects of demographic, socioeconomic, and farm characteristics on adoption of cover crops. Corn Belt is one of the most extensively farmed regions in the US. Cover crops, as discussed above, can prove to be very beneficial in extensively farmed areas. Hence, this study focuses in the Corn Belt region. The specific objectives of the study are to:

a. Determine which factors (demographic, socio-economic, and farm characteristics) significantly influence the adoption decision for cover crops by producers in the Corn-Belt area.

b. Determine the marginal effects, for those producers who use cover crops, of the factors significantly affecting the cover crop adoption decision.

## 1.6. General Procedure and Outline of the Thesis

After including an introduction to the overall thesis and introduction to cover crops in this chapter, the study will focus on previous research in the field in Chapter 2. It will basically include literature review on the benefits of cover crops in detail, concerns related to cover crops, technology adoption theory, and technology adoption in various fields of agriculture including

conservation practices and cover crops. Chapter 3 provides details about data, models, and the explanatory variables used in the analysis. Chapter 4 presents the descriptive statistics of the data, tests performed on the data, and research results. It will include the explanation of the significance of variables and impacts on the use of cover crops. The overall conclusions, limitations, and recommendations will be included in Chapter 5.

# CHAPTER 2

# LITERATURE REVIEW

This chapter is divided into four major sections. The first section focuses on the literature related to the benefits of cover crops. The second and the third sections focus on limitations of cover crops and the economics of using cover crops, respectively. The fourth section is composed of technology adoption in general and in agriculture.

## 2.1. Cover Crops and Their Benefits

Cover crops are generally included in a cropping system as ground cover to protect soil from erosion (Dabney *et al.*, 2001) or for nutrient management (Fageria *et al.*, 2005). Cover crops also provide other important benefits, such as soil quality enhancement, water quality improvement, weed management, pest management, and yield improvement of subsequent crops (Sarrantonio and Gallandt, 2003; Fageria *et al.*, 2005).

By the simple definition of cover crop, it is clear that one of the purposes of using cover crops is for the protection of soil, generally when a field is fallow. Soil erosion removes the top soil layer, which contains a large proportion of soil organic matter and soil nutrients, which ultimately reduces crop production (Fageria *et al.*, 2005). On fallow land, when rain falls, a seal or crust is formed on the soil surface. This may reduce water infiltration and increase runoff, resulting in an increase in the chance of soil erosion (Louw *et al.*, 1991). It is not possible to prevent the contact of rain droplets with soil, but there are ways to prevent crust formation on soil. Use of cover crops could be one solution to this problem. Cover crops provide cushion and prevent raindrops from directly striking the soil surface (Sarrantonio *et al.*, 2003). Leaves and stems of cover crops slow the rate of water flow and their roots hold soil, so that the water will not be able to erode the topsoil easily. Good water infiltration and reduction in runoff from rainfall significantly reduces soil erosion (Fageria *et al.*, 2005). Studies conducted in Western

Kentucky on a silt loam soil showed an 88% reduction in soil erosion for conventionally tilled soybean planted following double-cropped wheat, compared to no cover crop (Langdale *et al.*, 1991). Another study showed that conservation-tilled cover crops reduced soil erosion 47% on a Providence silt loam soil in Mississippi (Langdale *et al.*, 1991). The choice of cover crops depends on the desired outcomes (like controlling soil erosion, controlling pests, increasing profit, among others), the soil type, climatic conditions, and the crop preceding and following the cover crop, among others. Sarrantonio *et al.*, (2003) concluded that cereal rye has proven to be the most useful species throughout the colder areas of North America as a winter annual cover crop for erosion protection because of its capacity to germinate and grow quickly in cool weather and its deep and fibrous root system. Soil erosion is controlled by cover crops because of the increasing soil organic matter in the soil which improves soil water infiltration and water holding capacity.

Both cover crops and conservation tillage increase soil organic matter compared to conventional tillage without cover crops, but the two practices combined give the best result (Frye *et al.*, 1993). The breakdown of plant residues by soil microorganisms produces compounds that are resistant to decomposition like gums and resins. These compounds help soil particles stick together and form granules. Granulated soil has greater soil permeability and aeration, and better water holding capacity, so that seeds germinate quicker and root growth is easier (Clark, 2007; Hartwig *et al.*, 2002). Keisling *et al.* (1994) conducted cover crops experiments for 17 years on fine silty soil in Arkansas. Hairy vetch, elbon rye, and crimson clover were used as cover crops. One of the findings of the experimentation was that cover crops increased organic matter. More organic matter means good infiltration, less soil crusting, better ability of the soil to ameliorate and degrade herbicides, and better soil tilth. An increase in porosity (having space in between the soil granules to hold water or air) was also observed by

using a cover crop. This especially helps to hold water which ultimately increases soil moisture (Keisling *et al.*, 1994).

Utilizing soil and atmospheric nitrogen (N) is an important benefit of cover crops, which may even justify the extra cost associated with the use of cover crops (Clark, 2007). Proper growth of cover crops, good soil nutrient level, soil pH balance, adequate soil moisture, and proper nodulation are some of the factors that help cover crops to capture available nitrogen in soil and atmosphere (Sullivan, 2003). In a study by Dabney *et al.* (2001), it was noted that release of N from cover crops depended on species and growth stage of the crop and climatic condition, among other factors. Rapid mineralization of nitrogen by cover crops was advantageous in certain situations where crop nitrogen demand was high for early growth. On the other hand, slower release of N was beneficial for crops, like cotton, that have a relatively longer growing season and peak nitrogen demand occurs after mid-bloom. Hence, Dabney *et al.* (2001) emphasized the importance of synchronization of cover crop N release with the demand by the following crop. Finally, they concluded that legume/grain bi-culture was a better combination compared to legume monocultures as the combination can scavenge more soil and atmospheric nitrogen from both soil and atmosphere. To observe the amount of nitrogen provided by different cover crops in soil, Ebelhar *et al.* (1984) conducted field experiments from 1977 through 1981 in Kentucky. They found that hairy vetch as a winter cover crop provided a significant amount of N regardless of applied N fertilizer rates. Doran *et al.* (1991) showed that legume winter cover crops commonly accumulate from 60 to 150 lb/acre of nitrogen in the Eastern and Southeastern United States as compared to 30 to 40 lb/acre of nitrogen in the drier, cooler climates of the Corn-Belt area.

Daniel *et al.* (1999) conducted a study in Virginia on sandy loam soil from 1995 to 1997. The cover crop treatments were crimson clover, hairy vetch, hairy vetch with rye, rye, wheat, and

white lupin. The cover crop providing the best cover also produced highest biomass. Results of the study showed that, on average, rye produced more biomass (2,721 lb/acre) than any other cover crop treatment. The study also found out that cover crop biomass production was not affected by tillage treatment.

Pathak and Diaz-Perez (2007) conducted a field experiment in Southwestern Georgia with a basic winter cover crop (rye, crimson clover, subterranean clover, or cahaba vetch) followed by summer cash crops (cotton, peanuts). They found that insecticides and herbicides were rarely necessary after the third or fourth year of a rotation. No-till plots with cover crops and long rotations had few problems with pests like thrips, aphids, bollworm, and budworm. In this instance, research plots were insecticide free for 6 to 12 years afterwards. Some other producers used cover crops and crop rotations to economically produce vegetables like cucumbers, squash, peppers, eggplant, and cabbage, or row crops like peanuts, soybean, and cotton with only one or two applications of insecticides (Pathak and Diaz-Perez, 2007).

In addition to reducing the need for external inputs like fertilizers and pesticides, Pathak *et al.* (1991) showed that cover crops like blue lupin, vantage vetch, lentil, and crimson clover result in higher yields of marketable cucumbers when compared to no cover crop. Another study by Rothrock *et al.* (1991) demonstrated that, when planted as a winter cover crop, hairy vetch alone increased cotton yields compared to cotton without a cover crop. Hairy vetch with rye was even better at increasing cotton yields.

**2.2. Concerns over the Use of Cover Crops**

Cover crops need proper management to prove beneficial to the cropping system. Proper management includes selecting proper cover crop according to the land, climate, and soil condition; planting cover crops in the fallow land or in between cash crops to protect soil and get other benefits from cover crops; and killing cover crops to grow cash crops and to avoid

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disadvantages of over-grown cover crops. If cover crops are included in the system without taking care of these issues, the benefits of cover crops can prove disadvantageous and may affect the overall system in a negative way. Peet (1996) stated that if cover crops are left unmanaged, un-decomposed cover crop residues might interfere with the cash crop by producing unwanted allelopathic chemicals. Also, less nitrogen would be released if cover crop residue were not incorporated into the soil.

Water use by cover crops and the cash crops is also one of the major challenges associated with using cover crops (Gardner *et al.*, 1991). Thelen (2004) observed that, in the case of insufficient precipitation, a rye cover crop used the water and the yield of the cash crop decreased, so it was necessary to get rid of rye. Ebelhar *et al.* (1984) showed that soil moisture was significantly less under hairy vetch compared to corn residue. They also concluded that careful timing of planting cover crops, killing them, and planting corn was very important to prevent yield reduction of corn. This might be because both corn and legumes require soil moisture for seed germination. To avoid excessive winter-kill, legumes must become established before the severe winter weather and must be allowed to grow as late as is practical in the spring to provide maximum N. At the same time, attention must be given to the corn growing time to prevent corn yield reduction due to late planting.

Tollenaar *et al.* (1993) show that corn growth and development was reduced when corn was preceded by a winter rye cover crop. After two years of field research, they concluded that cover crops can reduce the yield of the cash crop by reducing N uptake due to immobilization of N fertilizer in soil. The result of Tollenaar *et al.* (1993), along with results from other studies and previous researchers strongly, suggested allelopathic effects of cereal cover crops on corn.

Bruce *et al.* (1991) states that benefits from cover crops may not show over short time frames of one or two years. Nonetheless, he states that, in the long run, both economical and environmental benefits of cover crop are undeniable.

## 2.3. Economic Analysis of Cover Crop Use

A study done by Schlaapfer *et al.* (2001) examines the economic importance of biotic control in limiting nitrate leaching and conserving soil resources in agricultural ecosystems. An objective function was developed that modeled welfare from both private income and agricultural production and public benefits from ecosystem services that are jointly produced within a managed agricultural ecosystem. The study concluded that extended use of cover crops may be highly desirable, assuming that groundwater contamination from nitrate leaching has high social cost. If the cost of planting mixtures of cover crop species is not prohibitively high, then increasing the functional diversity of cover crop species may also be cost-effective, although the optimal combination is yet to be found.

Hanson *et al.* (1993) studied the profitability of a hairy vetch system with no-till corn in comparison with winter wheat and winter fallow systems with no-till corn at two locations (Piedmont and Coastal Plain) in Maryland. A 3-year field study was conducted from 1986 to 1988 and four different nitrogen (N) fertilizer rates were applied for specific cover crops at each location at university recommended rates. The results of the study showed that, in both Piedmont and Coastal Plain soils, average no-till corn yield following hairy vetch was significantly higher than corn following winter fallow or winter wheat at comparable N rates. Among all combinations of N rates and cover crops, the highest corn yield in the Coastal Plain was after hairy vetch with 120lb N/acre; and in the Piedmont it was after hairy vetch with 40lb N/acre. In the Coastal Plain, the yield advantages of corn following hairy vetch appear to more than compensate for the expense of establishing hairy vetch, but this was not the case in the Piedmont.

Even the least profitable N rate for corn following hairy vetch (0lb N/acre) in the Coastal Plain was more profitable than the next best alternative, i.e., corn following winter fallow at 120lb N/acre. In both the locations, hairy vetch did not reduce profit maximizing N use, but increased the effectiveness of N. Thus, hairy vetch was more accurately a yield enhancer for no-till corn rather than an N substitute.

Hanson *et al.* (1993) also performed sensitivity analysis of the results with changes in the prices of hairy vetch seed, fertilizer, and herbicides. The result suggested that seed prices were unlikely to make the hairy vetch system economically unattractive. It also showed that, in both locations, the most profitable hairy vetch system would still be profitable even if N fertilizer were free. Finally, it showed that the hairy vetch system was still profitable, even after including the extra cost for the additional herbicide application.

Mallory *et al.* (1998) concluded that for cover crops, seed cost constituted almost three quarters of the total cost of using cover crops. A few other concerns regarding cover crop use were the possible need of extra machinery and labor. Most of these studies do not account for any long-term benefits, which is why most research related to cover crops concludes that cover crops are not economical.

**2.4. Technology Adoption**

"Diffusion of innovation is the process by which an innovation is communicated through certain channels over time among the members of a social system" (Roger, 2002, p.11). This statement by Rogers makes it clear that the four elements involved in the diffusion of innovation are: innovations, communication channels, time and the social system which will be discussed hereafter.

Rogers (2002) defined innovation as any idea, practice or object that is either new, has never been applied, or has not yet been adopted or rejected. Technology is a tool to help achieve

the expected results of the innovation. Technology adoption is as old as human history. It was hypothesized that the process started from gaining knowledge about fire and using it for cooking or learning about plants and selecting edible, usable ones out of all the available plants. Primitive levels of technology and its adoption from the very early stage have now been studied in a systematic manner (Rogers, 2002). Research on the diffusion of innovations started during 1940s and 1950s in various disciplines outside agriculture such as technology adoption in the manufacturing industry (Bartolini *et al.*, 2001).

All innovations are not desirable to all the individuals in a social system. Some innovations, for example a mechanical tomato picker, may be desirable to one group of a social system, like larger commercial tomato producers, while it may be harmful to the other potential adopters, such as small-scaled tomato producers. Most small-scaled tomato producers went out of business because a mechanical tomato picker was very expensive for them, given the size of their operations.

The rate of diffusion of an innovation differs from one innovation to another. The major characteristics of innovations that account for different rates of adoption are: relative advantage, compatibility, complexity, triability, and observability of the innovation compared to the existing knowledge.

Another element of diffusion of innovation is communication channel. A communication channel is a means through which new ideas get from one individual or group to another. Mass media channels like radio, television, and newspaper are regarded as the most rapid means of informing others about the new idea. Interpersonal channel, on the other hand, is person to person communication of ideas between two or more individuals. The interpersonal channel is more effective in persuading others to accept new ideas. Individuals generally do not evaluate innovations on the basis of results of scientific studies, but rather how effective it is for the first

individuals who adopt. Basically, for most individuals, the decision of adopting a new innovation depends on the evaluation of the innovation by other individuals in similar conditions to theirs.

A third element in the diffusion process is time. The "time" factor indicates the rate of adoption or the time an individual takes between knowing about an innovation for the first time to a point of adopting or rejecting it. Sometimes, the measurement of time gets criticized in research studies. The element, time, can be involved in a number of ways in the diffusion process, such as innovation-decision process, innovativeness and adopters category (e.g. innovator, early adopter, late adopter, non-adopter), and rate of adoption.

The fourth element in the diffusion of innovations is the social system. Social system is an interrelated group of individuals working on solving a common goal. Any individual, group, or organization could be considered a social system engaged to solve a common problem to reach a mutual goal. Innovation occurs within a social system and that innovation is either diffusing or is expected to diffuse within that social system.

"Innovation-decision process" is a five stage process through which an individual passes the first knowledge of an innovation, to the formation of an attitude towards that innovation, to a decision to adopt or reject the innovation, to implementation of the innovation, to the confirmation of that innovation. The first stage is called "knowledge" which is gained when someone learns about innovation and how it works. For example, use of cover crops; the first knowledge of what cover crops are and how to use cover crops in the cropping system can be considered as the first stage. The second stage is "persuasion". This happens when a person forms a favorable or unfavorable attitude toward the technological innovation. In the example, when a person or a group starts to form an opinion about the usefulness of cover crops, this is the persuasion stage. The third stage is the "decision" stage when a person either adopts or rejects the innovation. When a person or a group decides to either use or not to use cover crops in their

cropping system; this is the decision stage. The fourth stage is the "implementation" stage of the innovation, which is when an individual uses the innovation. The first time a farmer uses cover crops in the field shows implementation of an innovation. In some cases, during implementation, a user changes or modifies the innovation and that is called re-invention of the innovation. Not all innovations are re-invented. The fifth stage is the "confirmation" of the innovation, which occurs when an individual rechecks the results of an innovation and approves it by continuing to use it. In this example, the farmer evaluates the results of using cover crops, considers the benefits and detriments provided by cover crops, determines it was worth using, and continues to incorporate cover crops into the cropping system. (Rogers, 2002).

The rate of technology adoption can also be understood by studying why producers are rejecting the technology: either they are unable, or unwilling, or both (Nowak, 1992). Being unable to adopt new technology may be because of the lack of information, complexity of the system, limited availability of supporting recourses, excessive labor requirement, and so on. Unwillingness to adopt new technology could be due to conflicting information, poor applicability of the technology, the technology being inappropriate in their current system, chances of negative outcomes from using the technology, and so on (Nowak, 1992).

**2.4.1. Agricultural Technology Adoption**

As in other fields, many researchers have been studying technology adoption and its consequences to agriculture. There are a number of studies done in different areas of agriculture to study the rate of technology adoption, to see effects of various technologies in the existing agricultural system, and to see the factors affecting the adoption rate of technology. Rahelizatovo and Gillespie (2004) investigated the economic and non-economic determinant factors of producers' decisions to adopt twenty-one different best management practices (BMPs) by Louisiana dairy producers. Kim *et al.* (2006) analyzed the adoption of the use of Russian

varroa-resistant honey bees to deal with a parasitic mite (varroa), which is a very significant problem for beekeepers. Gillespie *et al.* (2004) focused on four different types of breeding technologies: weekly farrowing, intensive breeding, terminal crossbreeding, and artificial insemination in the U.S. hog production. Each of these breeding technologies differs from one another in the capital investment and managerial skills requirement. Apart from these, the literature shows numerous studies based on technology adoption in crops, some of which are discussed below.

Griliches (1957) provided one of the seminal studies in the field of technology adoption. The study focused on different factors related to the use of hybrid corn in various parts of the United States. The study divided the logistic growth curves for the adoption of hybrid corn in each region into three parts: the origins, the slopes, and the ceilings, and examined each part separately. Griliches (1957) defines the origin as the development of hybrid corn varieties for a particular area (usually by a seed producing firm), slope as the rate of adoption of the hybrid corn varieties in the area, and ceiling as the equilibrium use of the varieties in the area.

The difference in development of hybrid corn varieties for different areas (the origins) was explained on the basis of how much the seed companies could profit by producing hybrid corn seeds for those areas. The results implied that development of hybrid corn varieties for a particular area depends upon the expected pay-off for the seed companies. If the seed companies perceive that producing hybrid corn varieties for that area is profitable for them, they will do so.

The differences in rate of adoption (slope) and equilibrium use (ceiling) between various regions was explained by the profitability to farmers of shifting from non-hybrid to hybrid corn. It was found that the rate of adoption depended chiefly on the 'profitability' measures, i.e., average corn acreage per farm, average difference between yields from hybrid and open pollinated varieties, and the pre-hybrid yield. It was also found that the rate of adoption may also

be affected by advertising carried on by private seed companies and outreach efforts by extension agents. In terms of the ceiling (equilibrium use), it was found that the 'profitability' measures (i.e., average corn acres per farm and pre-hybrid yield, and capital per farm) had significant effects on the long run equilibrium use of hybrid corn. Griliches (1957) also concluded that in the long run, and cross-sectionally, sociological variables, like income, education, standard of living, among others, tended not to have significant effects, leaving the economic variables as the major determinants of the adoption of technological change.

Frisvold *et al.* (2009) studied the frequency of use of ten best management practices by corn, cotton, and soybean producers to control weeds. Count data analysis was done to explain the total number of BMPs frequently practiced and ordered-probit regression was carried out to explain the frequency of individual weed-resistance BMP adoption. The result from the count data analysis indicated that the number of BMPs adopted increased with the education level of the producers. It also showed that producers who expected to have yields greater than the county average tended to adopt more BMPs. The number of BMPs adopted to control weed resistance was lower in areas reporting more resistance problems and in counties with variable yields. The result of ordered-probit regressions showed less frequent use of multiple herbicides with different modes of action by soybean producers. It also showed that producers who expect yields higher than the county average were more likely to use multiple herbicides with different modes of action while producers in counties with greater yield variability less frequently used it. Overall, the study showed that cotton growers adopted BMPs more frequently compared to others. For all three crops, adoption of BMPs like cleaning equipment, using multiple herbicides with different modes of action, and supplemental tillage, were low. The remaining seven BMPs were practiced frequently by all three crop producers i.e. corn, cotton and soybean producers.

**2.4.2. Resource Conservation in Agriculture**

Caswell and Zilberman (1985) analyzed the factors affecting the adoption of alternative irrigation technologies by perennial crop growers in the San Joaquin Valley of California. The analysis shows the short-run estimates based on current behavioral patterns. Two equations were estimated using the maximum-likelihood estimation procedure, the first to estimate the odds of adopting sprinkler technology versus traditional technology and the second to estimate the odds of adopting drip technology versus traditional technology. They found that the farmers who used groundwater were more likely to adopt sprinkler and drip technologies than the farmers who used surface water. Also, the adoption of modern irrigation technologies depended on the types of crops grown. Finally, the study shows that proper use of water-price policies can induce the use of modern irrigation technologies.

Olive tree groves in mountainous regions are subject to a high risk of soil erosion and Calatrava-Leyva *et al.* (2005) examined factors that influenced adoption of soil conservation practices and the current level of adoption of such practices on olive tree farms in mountainous regions in Spain. For the analysis, three multivariate probit models using maximum likelihood estimation with three different soil conservation practices, namely tillage following contour lines, maintenance of terraces with stonewalls, and no-tillage with herbicides were used. In general, the decision of farmers adopting soil conservation practices was governed by various circumstances like the cost of adopting conservation practices, farmers' risk attitude, their perception of soil erosion, level of non-farm income, continuation of farming in the family, labor and machinery availability, and farm income. The results of the study indicated that if the farmer was an early adopter of technological innovations, used local extension services, was younger than 60, had inherited the farm, and planned everything in advance, the probability of adoption of tillage following contour lines would increase. On the other hand, if the farmer used

accounting only for tax purposes and not for managerial purposes, did not know about the existence of erosion agri-environmental schemes, and got technical information from professional organizations, the probability of adopting conservation practices would decrease. Similarly for the case of farms maintaining stonewalls, the probability would increase if the farmer used his own machinery and did not rent it, and used accounting for taxation purposes only. The probability would decrease if farm profitability was lower and if it had relied on EU subsidies. The probability of farmers adopting no-tillage with herbicides would increase if the farmer had relied only on family labor, and had used accounting only for taxation. The probability would decrease if the farmer was older than 60.

Bultena *et al.* (1983) compared some personal, attitudinal, and farm characteristics of farmers who adopted conservation tillage with those still practicing conventional tillage. The moldboard plow was very popular for seedbed preparation until the mid-1970s. After that, conservation tillage began to replace the moldboard plow system. The moldboard plow was criticized for wasting energy, reducing soil fertility, and contributing to soil erosion and the related problems of air and water pollution. Incorporating conservation tillage into one's farming system required different management skills. Positive results of conservation tillage were slowly realized, so some producers had doubts about the positive outcomes and, furthermore, they had to change various systems in their fields to incorporate a conservation tillage system. Researchers used analysis of variance and cross-tabulation to compare the three categories of adopters of conservational tillage. The results showed that the adopters of conservation tillage were younger, better educated, had larger farms, farms with greater potential for erosion, earned higher incomes, and were less risk- averse compared to non-adopters. The result also showed that adoption was implemented by producers who perceived widespread adoption of that technology in their community and the surroundings.

### 2.4.3. Cover Crops as Technology Adoption

Cover crop inclusion in the farming system is one of the various technologies whose adoption has been examined. In northern Honduras, with continuous development in agriculture systems, velvet bean (mucuna) was planted as part of the corn rotation. This boosted the corn yield along with biomass production, reduced labor use and the need for expensive fertilizers and herbicides compared to traditional corn system. The corn-mucuna system had generated widespread interest in Honduras because it diffused rapidly and spontaneously among farmers with little or no intervention. In spite of this popularity, after a few years, the survey showed a sudden decline in the number of farmers adopting and continuing the corn-mucuna system. Neill and Lee (1999) studied this and found four major factors that were affecting the adoption and abandonment of this technology: family and demographic attributes of the farm household like age or education; the physical characteristics of the farm, like soil, slope and farm size; economic factors such as input and output prices; and institutional factors, such as the land tenure regime and the availability of extension and information services.

The survey results showed that three-quarters of the farmers who owned land adopted the corn-mucuna system and later almost similar percentages of farmers abandoned it. It was found that, unexpectedly, the age of head of household and visitation by an extensionist were non-significant. According to the survey, the major reasons given for abandonment were problems with Rottboellia or other grasses, and reclamation of the plot by the landlord. The empirical results showed that the practice of annual reseeding of mucuna positively influenced adoption. On the other hand, the proportion of land sown to corn, cultivation of a high-value crop, farmers having problems with weeds and farmer having problems with rottboellia, had significant and negative influence on the continuation of the rotation. The insignificance of the number of cattle owned by a farmer with corn-mucuna abandonment was surprising.

In the case of corn-mucuna rotation abandonment, changes in variables like tenure security, shifting land markets, and the rise of extensive cattle were not statistically significant. As was seen, abandoners did not make more profit than adopters; a disutility associated with corn production in the steep hills of Honduras was thought to be the only reason.

Singer *et al.* (2007) used survey data from four Corn-Belt states: Illinois, Indiana, Iowa, and Minnesota, to study the use of cover crops in the central western U.S. Corn-Belt. They state that anecdotal evidence showed comparatively lower use of cover crops in the farming system, despite the presence of a wealth of knowledge about their benefits. Thus, this study was carried out to quantify the use of cover crops in the U.S. Corn-Belt and to identify the factors associated with their adoption.

Singer *et al.* (2007) carried out four logistic regressions, one for each state, each trying to explain the adoption of cover crops with the help of variables like number of acres farmed, the number of crops farmed, importance of crops or livestock, use of conservation practices, and the farmer's receipt of incentives. The results of their analysis showed that the number of crops grown on a farm was a significant factor affecting cover crop use for all states except Iowa. Also, perceived yield advantage or soil quality improvement on the part of the producers had a positive effect on the adoption of cover crops. Producers quoted many reasons for not using cover crops, some of which included: too much time involved, too costly, no runoff problem, already using no-tillage practices, and lack of enough knowledge about cover crops. The producers also noted soil erosion, crop diversity, and adding soil organic matter as the most important reasons for using cover crops. Information on the cost of using cover crops was listed as an important factor. The study also observed that cost sharing could increase the use of cover crops among Corn-Belt farmers.

# CHAPTER 3

## DATA AND METHODOLOGY

This chapter is divided into three parts. An overall description of the survey conducted by Singer *et al.* (2007) is included in the first part. The second part contains a description of the data. The third part contains a description of the econometric model used for the analysis.

### 3.1. Survey Material and Methods

#### 3.1.1. Survey Design

Corn-Belt is the most extensively farmed area in the U.S. Cover crops have various benefits which will help improve the overall soil quality that is bound to be degraded as a result of extensive farming. Singer *et al.* (2008) noted that the use of cover crop in the Corn-Belt has been declining. Given this fact, study of factors influencing cover crop adoption in the Corn-Belt will provide an insight into what may be done to influence the rate of adoption of cover crops.

This study uses data collected from a mail survey administered by Singer *et al.* (2007). This dataset provides information that is important in meeting the objectives of the study. They collected data from the producers actively farming in 2006 in four Corn-Belt states in the U.S.: Illinois, Indiana, Iowa, and Minnesota. The sample was drawn from a database maintained by Survey Sampling International that contains information on individuals (i.e. names, addresses, and occupation codes). The questionnaire data set contains information gathered about producers' conservation practices, knowledge of cover crops, attitudes about growing cover crops, growing of cover crops (ever and in the past five years), advantages of growing cover crops, reasons for not growing cover crops, cost of growing cover crops, and cover crop influence on yield. (See Appendix A for a copy of the survey questionnaire).

In the first section, producers were asked about their age, farming experience, farm size, education level, gender, what they grew in their farm, and whether they were involved in any

conservation practices. Most of these questions were binomial, discrete categorical questions. Others were continuous and asked producers how many hours per week they worked off-farm, age, years of farming experience, acres of land owned, and acres rented. The second section of the questionnaires focused on cover crops. In this section, producers were asked questions such as how familiar they were with cover crops, use and management of cover crops, and what they thought were advantages of cover crops. Additionally, producers were asked about cost sharing to grow cover crops, and reasons for never growing or having stopped using cover crops. Producers were asked about where they got information about cover crops, have they noticed an increase or decrease in yields after using cover crops, and if they had equipment needed to plant cover crops.

### 3.1.2. Survey Statistics

For sampling purposes, a producer was defined as any person whose occupation involved producing cash grains (i.e. corn, soybean, wheat), or operated a general farm whose primary enterprise was crop production. A stratified random sample of 3,500 producers were selected (875 from each of the four states), targeting at least 250 completed responses per state. Illinois, Indiana, Iowa, and Minnesota farmers returned 258, 253, 316, and 269 responses, respectively, for a total of 1,096 completed surveys. The overall response rate was 36.1% for the survey, after adjusting for producers not farming in 2006. The response rates for the each state were: 33.9% for Illinois, 33.6% for Indiana, 42.1% for Iowa, and 35.0% for Minnesota. This survey response seems to be higher than the other survey research response (Bergtold et al., 2010).

A simple observation of data from the survey gives an overall picture of demographic characters of the producers, their perspective regarding cover crops use and their benefits, and the experience of producers who used cover crops. Table 3.1 contains information on the age and farming experience of the producers in the Corn-Belt region of the U.S. A total of 1,074

producers responded to the question asking about the number of years farming and 56% (606 of 1,074 ) of them had 20 to 40 years experience, while 26% (276 of 1,074) had been farming for more than 40 years. The youngest producer participating in the survey was 26 years old from Illinois, and the oldest was 96 years old, from Indiana.  The highest percentage of producers, 31% (335 of 1,091), fell in the age range of 56 to 65 years, followed by 30% (328 of 1,091) who were 46 to 55 years. Age and experience data indicate that the farming population is aging and a majority of respondents had significant farming experience.

**Table 3.1: Age and Experience of the Producers in the Survey**

|  | Description |  |  |  |  |  |  |  | Total Response |
|---|---|---|---|---|---|---|---|---|---|
| Experience | No. of years farming | Years | ≤10 | 11-20 | 21-30 | 31-40 | 41-50 | >51 |  |
|  |  | No. of producers | 48 | 144 | 326 | 280 | 192 | 84 | 1,074 |
| Age | Age of the producer | Years | ≤35 | 36-45 | 46-55 | 56-65 | 66-75 | >76 |  |
|  |  | No. of producers | 18 | 96 | 328 | 335 | 213 | 101 | 1,091 |

Figure 3.1 depicts information about the farm ownership of the respondents. Almost 59% (638 of 1,084) of the respondents have farms smaller than 600 acres. There are only 6 producers with farms larger than 6,000 acres and 26 % of producers (284 of 1,084) have farms with less than 200 acres. Around 53% of the respondents (573 of 1,083) stated that they own 200 acres or less of land, 23% (257 of 1,083) own between 200 and 400 acres, and 10 % (110 of 1,083) own between 400 and 600 acres.

According to the survey data, 98% (1,074 of 1,094) of the respondents were male and 68% (714 of 1,049) were farming full-time. Many respondents, 40% (432 of 1,092), held high school diplomas and only 5% (56 of 1,092) held graduate degrees. Almost 59% (637 out of 1,080) of the respondents said that they only grow crops while less than 1% (10 of 1,080) of the producers raise livestock only. The rest (40%) produce both crops and livestock (Figure 3.2).

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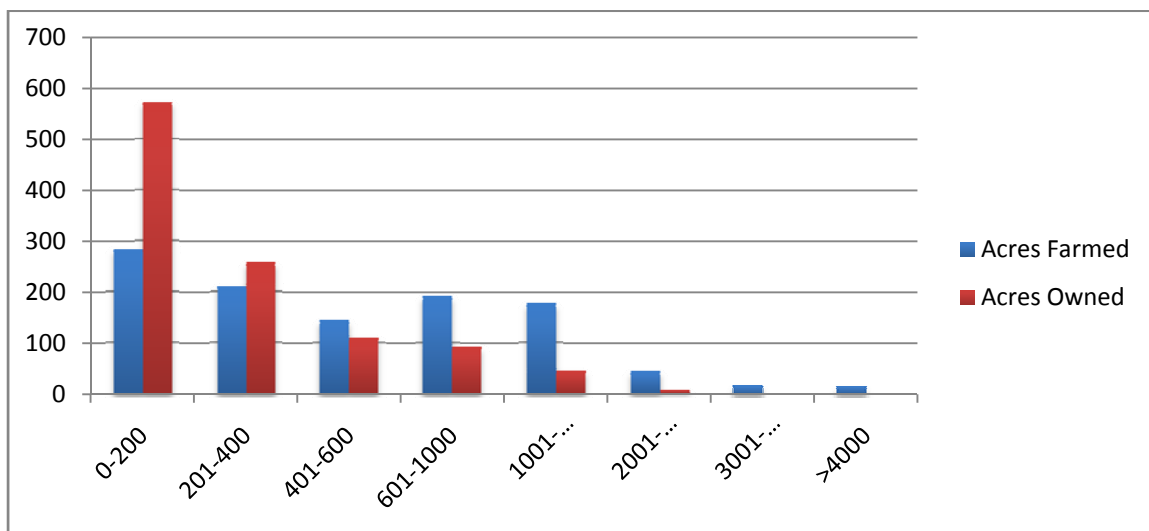
**Figure 3.1: Farm ownership of the respondents of Corn-Belt region in 2006**
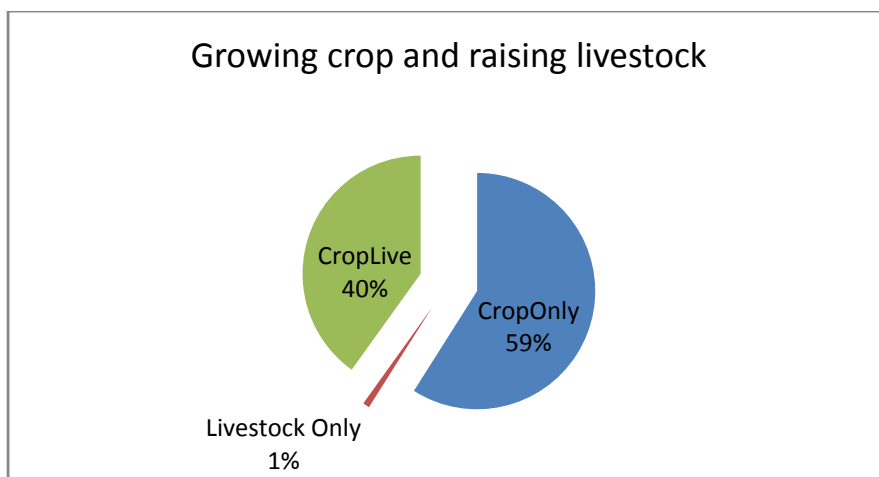


**Figure 3.2: Producers growing crop, raising livestock and both**

Table 3.2 includes miscellaneous information about the respondents. A majority of the respondents, 60% (751of 1,087) did not work off-farm. Farming certified organic land was not common among the surveyed population. Among respondents, 99% (1,071 of 1,078) answered "no" to the question asking if they farm land that is certified organic. According to the survey, 42% of respondents (452 of 1,072) indicated that their farms participated in some form of government conservation program and 79% (849 of 1,074) indicated that they implemented

conservation practices other than via government conservation program. Of the producers who implemented other conservation practices, 42% (357 of 849) indicated that they received some cost share incentives for those conservation practices. For the producers receiving cost share, 54% (194 of 357) indicated that they would have implemented that conservation practice without the cost share incentive. It seemed that the respondents would adopt the conservation practices if they perceived that practices were important to their farm, even without incentives. However, incentives might attract other producers, who did not perceive conservation practices to be as important to their farming systems, to use them.

**Table 3.2: Miscellaneous information about the respondents**

| Variable | Description | Responses | | Total |
|---|---|---|---|---|
| | | Yes | No | Response |
| Off-farm employment | If the producers work off-farm | 336 | 751 | 1,087 |
| Organic | If the farm is certified organic | 7 | 1,071 | 1,078 |
| GovCons | If producer's farming land is in a government conservation program like CRP, WRP, or EQIP | 452 | 620 | 1,072 |
| OtherPrac | If farm is in some other conservation practices such as conservation tillage, spring vs. fall nitrogen application, waterways, etc | 849 | 225 | 1,074 |
| Incentives | If the producer gets any cost sharing incentive or income for using some conservation practices | 357 | 483 | 840 |
| Adopted | If the producers would have adopted the practices without incentives | 194 | 146 | 340 |

Table 3.3 presents various information regarding cover crops use and management. Among 1,052 respondents, 55% indicated that they had enough information about cover crops to make decisions about crop selection, use, and management. If cost sharing was available, 56% of respondents (500 of 884) indicated that they would plant cover crops. For the question about having a grain drill or other equipment needed to plant cover crops, 59% of respondents (615 of 1,041) answered that they have a grain drill or other equipment. Among the producers that

responded, 33% (296 of 905) indicated that they would use cover crops if they could hire someone else to plant them.

**Table 3.3: Various information about cover crops users**

| Variable | Description of the variable | Response | | Total respondents |
| --- | --- | --- | --- | --- |
| | | Yes | No | |
| Informed | Have enough information about cover crops to make decision about its selection, use and management | 584 | 468 | 1052 |
| Cost Sharing | If cost sharing were available, would you use cover crops | 500 | 384 | 884 |
| GrainDrill | If the producers have grain drill or other equipment to plant cover crops | 615 | 426 | 1041 |
| Custom Plant | Willing to use cover crops if you could hire them custom planted | 296 | 609 | 905 |

Producers were asked about their familiarity with cover crop use and management using a Likert type scale with "1" being not familiar at all to "5" being very familiar with cover crops. Out of 1,053 respondents, 23% denoted 1, 16% denoted 2, 29% denoted 3, 17% denoted 4, and 15% denoted 5. When asked about what they were willing to spend to plant cover crops, 66% (429 of 648) respondents indicated that they were willing to spend between $1 to $20 per acre, 1% (9 of 648) indicated between $81 to $98, and 18% (118 of 648) indicated that are not willing to spend any extra money to plant cover crops. Among 560 respondents, 61% indicated that they would need minimum payment between $1 to $20 per acre to plant cover crops.

Table 3.4 contains the responses of the producers towards the questions regarding their perception about the advantages of using cover crops. A total of 976 producers responded for the query about their perception of cover crop advantages. The respondents perceived reduction of soil erosion (96%), decreasing run off (82%), and increasing organic matter content of the soil (75%) as the most important advantages of using cover crops. Around 54% of the respondents also agreed that cover crops help increase water infiltration and 28% indicated that cover crops help increase yield of the cash crops. However, only 12% indicated that cover crops help reduce the incidence of pests.

**Table 3.4: Producers perception of whether or not cover crops had these advantages (976 respondents)**

| Variables | Variables Description | Response | |
|---|---|---|---|
| | | Yes | No |
| Erosion | Reduces soil erosion | 935 | 41 |
| Infiltration | Increases water infiltration | 528 | 448 |
| Runoff | Decreases runoff | 796 | 180 |
| Organic | Increases organic matter in soil | 729 | 247 |
| Compaction | Reduces soil compaction | 372 | 604 |
| Weeds | Suppresses weeds | 504 | 472 |
| Yield | Increases yield | 272 | 704 |
| Pests | Lowers pest incidence | 114 | 862 |

**Table 3.5: Sources of information that producers used for cover crop selection, use, or management**

| Variables | Variables Description | Response | | Total |
|---|---|---|---|---|
| | | Yes | No | Response |
| Coop | From local co-op | 134 | 827 | 961 |
| Farmers | From other farmers | 262 | 695 | 957 |
| Agribus | From agribusiness like seed or chemical company | 154 | 803 | 957 |
| Extension | From University Extension | 275 | 684 | 959 |
| NRCS | From National Resources Conservation Services | 186 | 772 | 958 |
| SWCD | From Soil and Water Conservation District | 285 | 675 | 960 |
| ARS | From Agricultural Research Service | 42 | 916 | 958 |
| Other | From any other sources of cover crop information | 95 | 866 | 961 |

Producers indicated that sources of information they most often use for the selection, use, and management of cover crops were the local Soil and Water Conservation District office (30%), university extension service (29%), and other farmers using cover crops (27%) (Table 3.5). Other sources include agribusinesses (16%) and local co-ops (14%). Seed dealers are the

most frequently used source for cover crop seeds (44%) followed by local co-operatives (37%).

Some of the producers save their own seed from previous years (21%) while others get their

seeds from other producers in their area (18%) (Table 3.6).

**Table 3.6: Source of cover crop seed that producers used (177 respondents)**

| Variables | Description | Responses | |
|---|---|---|---|
| | | **Yes** | **No** |
| SourceCoop | Local co-op | 65 | 112 |
| SourceDealer | Seed dealer | 78 | 99 |
| SourceFarmer | Other farmer | 32 | 145 |
| SourceSelf | Save own seed from previous year | 38 | 139 |

**Table 3.7: Reasons for never planting cover crops (788 respondents)**

| Variables | Description | Response | |
|---|---|---|---|
| | | **Yes** | **No** |
| Knowledge | Not enough knowledge about cover crops | 306 | 482 |
| NoTill | Already use no till practices | 300 | 488 |
| Time | Too much time involved | 278 | 510 |
| NoRunOff | No runoff problem | 226 | 562 |
| Cost | Too costly | 217 | 571 |
| NotDone | Just not done | 126 | 662 |
| Nutrients | Cover crop takes nutrients (nitrogen) from cash crop | 115 | 673 |
| Renter | Not a land owner but a renter | 90 | 698 |
| Dry | Too dry and cover crop takes water from cash crop | 77 | 711 |
| Pests | Cover crops attract unwanted pests | 65 | 723 |
| Weeds | Invasion weeds are hard to control | 58 | 730 |
| Yield | Cover crop reduce crop yield | 52 | 736 |
| Other | Other reasons | 100 | 688 |

Out of the 788 respondents who never used cover crops, 39% indicated that a lack of knowledge about cover crops was the reason they never planted cover crops (Table 3.7). Interestingly, 38% say that they already use no till practices of some kind, and hence do not feel using cover crops provides further benefit. Other major reasons given were that it took too much time (35%), that they have no run-off problem (29%), and that cover crops were costly (28%).

**Table 3.8: Reasons given for ceasing to use cover crops (64 respondents)**

| Variables | Description | Response | |
|---|---|---|---|
| | | Yes | No |
| Cost | Too costly | 28 | 36 |
| Time | Too much time involved | 25 | 39 |
| NoRunOff | No runoff problem | 12 | 52 |
| Nutrients | Cover crop takes nutrients (nitrogen) from cash crop | 7 | 57 |
| Yield | Cover crop reduce crop yield | 6 | 58 |
| Weeds | Invasive weeds are hard to control | 6 | 58 |
| Dry | Too dry and cover crop takes water from cash crop | 4 | 60 |
| Pests | Cover crops attract unwanted pests | 3 | 61 |
| Renter | Not a land owner but a renter | 3 | 61 |
| Other | Other reasons | 29 | 35 |

Out of the 64 respondents who stopped using cover crops, 44% cited high cost as the reason they stopped. An interesting observation here is that the average farm size of these producers (648.6 acres) was less than both the average farm size of the entire sample (777 acres) and the average size of the producers continuing to use cover crops (1,004 acres). This might suggest that producers with smaller holdings may be more cost-conscious about management changes. The next common reason given was the amount of time needed for managing cover crops (39%). Some producers indicated that they did not have a runoff problem (19%) and that

cover crops utilize nutrients meant for cash crops (11%) as reasons for ceasing to use cover crops. Other major reasons given were that cover crops reduce yield of the cash crop (9%); that they make weed control difficult (9%); that the soil was too dry for a cover crop (6%); or that they make pest control difficult (5%). Table 3.8 has the details of these responses.

Out of 180 respondents, 51% said they did not grow cover crop in 2005, while 41% said they had fewer than 100 acres of cover crop planted. Only 8% planted more than 100 acres of cover crops. Out of 166 respondents, 45% indicated that they plant cover crops on land they owned, 13% said that they plant cover crop on rented land, and 42% plant cover crops on both owned and rented land. The most popular method of planting cover crops was by using a grain drill, with 67% of the total respondents reporting this method. The majority (67%) of respondents said that they do not harvest cover crops, 27% harvest cover crops for animal feeds, and the remaining 10% harvest them for another use. 54% said that they used chemicals for killing cover crops.

**Table 3.9: Cover Crop User's Experience**

| Variable | Description | Response | | Total |
|---|---|---|---|---|
| | | Yes | No | Response |
| CustomHire | Do you custom hire your cover crop planning? | 20 | 156 | 176 |
| Kill | Did you have to kill a cover crop because it did not winter kill? | 124 | 60 | 184 |
| RecIncentives | Received any cost sharing incentives for using cover crops | 14 | 170 | 184 |
| Fulfill | If using cover crop fulfills any requirements for conservation plans | 73 | 105 | 178 |

Table 3.9 provides details about cover crop use. Out of 184 respondents, 67% indicated that they had to kill cover crops because they did not winterkill. Around 92% of the respondents indicated that they did not receive any cost sharing incentives for using cover crops. More than 55% of respondents indicated that using cover crops does not fulfill any requirements for the conservation plans on their farm. These data showed that a majority of the respondents had to

spend extra money to kill cover crops (67%), they did not receive any incentives for using cover

crops (92%), and using a cover crop did not fulfill conservation plan requirements (59%).

## 3.2. Model

Discrete choice models are econometric models that analyze the behavior of decision

makers when they have a finite set of alternative choices, compared to a continuous variable

(Greene, 2003). These models establish a statistical relationship between an individual's choices,

attributes, and the attributes of the alternatives available. Depending on the number of

alternatives available, discrete choice models can be binomial choice models (only two

alternatives available), or multinomial choice models (more than two alternatives available)

(Kennedy, 2008).

### 3.2.1. Multinomial Logit Model

When there are more than two alternatives, multinomial logit models could be used.

Given the response categories in this research, it is possible for the respondents to be divided into

three distinct groups: those who never used cover crops, those who used cover crops in the past

but not recently, and those who are currently using cover crops.

The probability of a producer falling into a particular one of these groups is

$p_{ij}$ = P [ Individual i choices alternative j ]

Here, the alternative choices are: not a cover crop user (N), past cover crop user (P), and

recent/current cover crop user (R). So the multinomial logit expresses the probability of a

producer, i, choosing alternatives j = N, P, R respectively as:

$$p_{iN} = \frac{1}{1 + \exp(\beta_{NP} + \beta_{PP}x_i) + \exp(\beta_{NR} + \beta_{PR}x_i)}$$

$$p_{iP} = \frac{\exp\left(\beta_{NP} + \beta_{PP}x_i\right)}{1 + \exp(\beta_{NP} + \beta_{PP}x_i) + \exp\left(\beta_{NR} + \beta_{PR}x_i\right)}$$

$$p_{iR} = \frac{\exp\left(\beta_{NR} + \beta_{PR}x_i\right)}{1 + \exp(\beta_{NP} + \beta_{PP}x_i) + \exp\left(\beta_{NR} + \beta_{PR}x_i\right)}$$

Here $\beta_{NP}$ and $\beta_{PP}$ are specific to the second (past cover crop user) alternative, and $\beta_{NR}$ and $\beta_{PR}$ are specific to the third (recent cover crop user) alternative. The parameter specific to the first alternative is set to zero to solve an identification problem.

The marginal effect for the continuous variable in the multinomial logit is given by

$$\frac{\Delta p_{ij}}{\Delta x_i}\bigg|_{all\ else\ constant} = \frac{\delta p_{ij}}{\delta x_i} = p_{ij}\left[\beta_{2j} - \sum_{j=1}^{3}\beta_{2j}p_{ij}\right]$$

The marginal effect for the dummy variable in the multinomial logit is given by the difference in the probabilities for the two values of dummy variables. Let's say x is a dummy variable and $x_a$ and $x_b$ are the two values of x. Then,

$$\widetilde{\Delta p_1} = \frac{1}{1 + \exp(\tilde{\beta}_{NP} + \tilde{\beta}_{PP}x_b) + \exp\left(\tilde{\beta}_{NR} + \tilde{\beta}_{PR}x_b\right)} - \frac{1}{1 + \exp(\tilde{\beta}_{NP} + \tilde{\beta}_{PP}x_a) + (\tilde{\beta}_{NR} + \tilde{\beta}_{PR}x_a)}$$

The odds ratio in multinomial logit function is another useful interpretive measure. It identifies how much more likely one category is to be chosen relative to another category. The odds ratio is given by

$$\frac{P(y_i = j)}{P(y_i = 1)} = \frac{p_{ij}}{p_{i1}} = \exp\left(\beta_{1j} + \beta_{2j}x_i\right)$$

where j = 2, 3

The odds ratio in multinomial logit expresses that the odds of choosing one alternative (i) rather than another alternative (j) does not depend on the other alternatives present in the study. This means that the odds between any pair of alternatives are independent of irrelevant alternatives (IIA) which is a strong assumption in logit models. If this assumption is violated, the

multinomial logit may not be a good modeling choice. To test for this assumption, the Hausman test and Suest test were performed. When the IIA assumption does not hold, other models like the multinomial probit, or nested logit could be used, among others (Green, 2003). The problem with these models is their complexity and applicability. Another alternative may be to approach the problem in a simplified way using binomial models.

A simple way to model binomial variables is to use a linear function called linear probability model. The linear probability model uses a straight line to predict the value of regression function. This works fine if the function is exactly or close to being a straight line. On the other hand, if the regression function is not exactly a straight line, most of the data will fall outside the predicted line. Also, the probability of the predicted value of the regression function may fall below 0 (minimum bound) or above 1 (maximum bound) at many points. This creates logical inconsistencies (Hill, 2007). A way to avoid this is to use a non-linear function. Popular choices for 'S' curves which are bounded to the range [0, 1], whatever the values of the explanatory variables, are logit or probit models (Grichilies, 1957).

The choice of logit and probit model depends on the distribution of the error term. The probit model assumes the errors to be distributed normally while the Logit assumes them to follow a logistic distribution. The logistic distribution is very similar to the normal distribution, except in the tails, which are considerably heavier. "There are practical reasons for favoring one distribution over the other in some cases for mathematical convenience; however it is very difficult to justify the choice of one or the other on theoretical grounds. In most applications, the choice between these two seems not to make much difference"(Greene, 2003, p. 667).

Various studies analyzing factors affecting technology adoption have used the logit model. Soule *et al.* (2000) used a logit adoption model to analyze the influence of land tenure on the adoption of conservation practices by U.S. corn producers. Grisham (2007) analyzed the

factors associated with the adoption of computerized record keeping systems and internet usage by dairy producers using logit model. Singer *et al.* (2007) performed a state-wise study of the factors associated with the adoption of cover crops by producers in four central western Corn-Belt states in the U.S. Following the same, this study used the logit model for the analysis of factors affecting adoption of cover crop.

**3.2.2. Logit Model**

Mathematically, the logit model is represented as

$$Prob \ (Y = 1 \ |x) = \frac{e^{x'\beta}}{1 + e^{x'\beta}} = \Lambda(x'\beta)$$

where x represents all the independent variables and β represents the effect of changes in x in the probability of adoption. The notation $\Lambda(.)$ is used to represent the logistic cumulative distribution function. The parameters of the model do not represent the marginal effect given by the parameters on the conventional Ordinary Least Square (OLS) regressions.

The marginal effect for the logit model for a continuous variable is given by

$$\frac{\delta E \ [y \ |x \ ]}{\delta x} = \Lambda(x'\beta)[1 - \Lambda(x'\beta)]\beta$$

And, the marginal effect for the logit model for a binary independent variable (d) is given by

$$Prob[Y = 1|\overline{x}_{(d)}, d = 1] - Prob[Y = 1|\overline{x}_{(d)}, d = 0]$$

where $\overline{x}_{(d)}$ represents the means of all the other variables in the model.

In the study, two logit models were estimated. The first model estimated was:

$$Y_1 = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10}$$
$$+ \beta_{11} X_{11} + \beta_{12} X_{12} + \beta_{13} X_{13} + \beta_{14} X_{14}$$

where,

$Y_1$ = Plantedcc = if the producers have ever planted cover crops in their farms (0 if no, 1 if yes),

$X_1$ = YearsFarmed = Number of years farmed,

$X_2$ = Hrsweek = Number of hours worked off-farm per week,

$X_3$ = Acresfarmed = Total acres farmed by the producer (farm size),

$X_4$ = Propowned = The proportion of land owned by the producer. It is the ratio of land owned to the farm size,

$X_5$ = College = if the producer has a college degree or more (1 if yes, 0 if no),

$X_6$ = CropLive = A dummy variable indicating if the producer grows crops and raises livestock both (1 if yes, 0 if no),

$X_7$ = CornSoy = A dummy variable for a producer growing corn and/or soybean (1 if yes, 0 if no),

$X_8$ = Smallgrain = A dummy variable for a producer growing either wheat or oats (1 if yes, 0 if no),

$X_9$ = Co-op = A dummy variable to account for producer who gets information about cover crops from local cooperatives (0 if no, 1 if yes),

$X_{10}$ = Farmers = A dummy variable for a producer who gets information about cover crops from other farmers (0 if no, 1 if yes),

$X_{11}$ = Extension =A dummy variable for a producer if he gets information about cover crops from University extension services (0 if no, 1 if yes),

$X_{12}$ = Illinois = A dummy variable indicating the producer is from Illinois (0 if no, 1 if yes),

$X_{13}$ = Indiana = A dummy variable indicating the producer is from Indiana (0 if no, 1 if yes), and

$X_{14}$ = Minnesota = A dummy variable indicating the producer is from Minnesota (0 if no, 1 if yes).

The second model estimated was:

$$Y_2 = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10}$$
$$+ \beta_{11} X_{11} + \beta_{12} X_{12} + \beta_{13} X_{13} + \beta_{14} X_{14}$$

where,

$Y_2$ = Past5yrs = if the producer had planted cover crops on his farm in the past five years (1 if

yes, 0 if no).

All the independent variables in the second equation are same as the first equation and are described as earlier.

The first model analyzes the factors affecting the adoption of cover crops in the Corn-Belt area by producers if they were ever cover crop users. The second model was estimated to see if there were any changes in the factors affecting the adoption of cover crops in the Corn-Belt area with time (in the past 5 years). Estimation of these two models together will help identify the factors influencing the adoption of cover crops in the Corn-Belt and the change in the influence of factors with time in the adoption decision, if any. In both models, Iowa is used as the reference state.

# CHAPTER 4

## DESCRIPTIVE STATISTICS AND RESULTS

This chapter contains the results of the study. The first section contains descriptive statistics and the second section contains statistical tests. The third section includes the list and explanation of explanatory variables included in the econometric model. The fourth section includes the results from the multi logit and logit analyses.

### 4.1 Descriptive Statistics

General summary statistics of the important variables used in the analysis may help us better understand the data. This section has three tables. The first, table (Table 4.1) presents a summary of all respondents, the second table (Table 4.2) has general statistics of explanatory variables by the producers ever having grown a cover crop, and the third table (Table 4.3) includes general statistics by producers having grown cover crop in the past five years. Appendix B contains summary statistics for all the data in the survey, comparing the information between producers who used cover crops and those who did not. Appendix C contains the summary statistics providing similar comparisons between producers who planted cover crops in the past five years and those who did not.

Table 4.1: Descriptive Statistics of the explanatory variables

| Variable | N | Mean | Std Dev | Minimum | Maximum |
|---|---|---|---|---|---|
| YearsFarm | 1075 | 32.788 | 12.790 | 1.000 | 70.000 |
| HrsWeek | 1072 | 11.011 | 18.691 | 0 | 80.000 |
| AcresFarmed | 1084 | 776.968 | 935.745 | 0 | 7000 |
| PropLandOwned | 1068 | 0.610 | 0.666 | 0 | 14.200 |

Table 4.1 has the overall description of continuous explanatory variables. The average number of years farming of the respondents was 33. On average, respondents worked 11 hours

per week off-farm. The average farm size was 777 acres, of which 61% was owned by the producer.

**Table 4.2: Descriptive Statistics of explanatory variables by producers ever growing cover crops**

| Variable | Never a cover crop user | | | | | Grown cover crop (ever) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | Mean | Std.Dev. | Min | Max | N | Mean | Std.Dev. | Min | Max |
| YearsFarm | 863 | 32.432 | 12.606 | 1 | 66 | 196 | 34.128 | 13.392 | 4 | 70 |
| HrsWeek | 861 | 11.231 | 18.897 | 0 | 80 | 197 | 10.071 | 17.842 | 0 | 60 |
| AcresFarmed | 870 | 752.098 | 885.190 | 0 | 7000 | 200 | 906.200 | 1119.55 | 10 | 7000 |
| PropOwned | 856 | 0.601 | 0.711 | 0 | 14.2 | 199 | 0.623 | 0.408 | 0 | 3.03 |

In Table 4.2, the descriptive statistics for the continuous explanatory variables are presented for producers who never used cover crops and for those who had ever used cover crops. As can be seen, there are more producers who have never grown cover crops. Noteworthy is the fact that producers with more experience are more likely to have grown cover crops. Result of t-test shows that the average number of years farmed was significantly greater for those who used cover crops compared to those who did not. Producers who have never grown cover crops have, in general, smaller farms than those who have grown cover crops, as confirmed by t-test. Result of t-test also shows that producers who grow cover crop have higher proportion of land owned than those who do not. (See Appendix D for t-test results.)

**Table 4.3: Descriptive Statistics of explanatory variables by producers growing cover crops in the past 5 years**

| Variable | Not a cover crop user in the past 5 years | | | | | Cover crop user in the past 5 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | Mean | Std.Dev. | Min | Max | N | Mean | Std.Dev. | Min | Max |
| YearsFarm | 930 | 32.670 | 12.603 | 1 | 66 | 123 | 33.236 | 13.95 | 5 | 70 |
| HrsWeek | 927 | 11.249 | 18.857 | 0 | 80 | 125 | 9.808 | 17.84 | 0 | 60 |
| AcresFarmed | 939 | 751.20 | 880.850 | 0 | 7000 | 125 | 1004.40 | 1255.24 | 10 | 7000 |
| PropOwned | 924 | 0.607 | 0.693 | 0 | 14.2 | 125 | 0.587 | 0.407 | 0 | 3.03 |

Table 4.3 summarizes the details of explanatory variables used in the analysis, by recent cover crops users. The mean for number of years farming, total hours of off-farm work per week, total acres of land in farming, and the proportion of land owned are given below. Result of t-test shows that the only variable significantly differing between the two groups, i.e., those who have used cover crops in the past five years and those who have not, is AcresFarmed.

## 4.2. Statistical Tests

Multicollinearity is a degree of linear relationship among some or all explanatory variables in the model (Gujarati, 1998). Presence of multicollinearity might create problems in regression analysis (Greene, 2003). The regression coefficients possess large standard errors which imply that the coefficients cannot be estimated with great precision. A simple correlation analysis using STATA was done to test whether any of the explanatory variables show high degrees of correlation. Correlation coefficients of 0.8 or more between any two independent variables tend to be problematic for regression analysis (Gujarati, 1998). Since none of the explanatory variables used in the model have correlation coefficients greater than 0.39, multicollinearity is not expected to be a problem in the analysis. Appendix E contains the correlation matrix for all the explanatory variable used in the model.

## 4.3. Expected Effects of Explanatory Variables

The variables that impact directly or indirectly on the research questions are included in the study. The factors considered in this study include experience, off farm employment, farm size, level of education of the producers, contacts with the external specialized personals, off-farm income, crops grown, and the states where the farms are located.

Number of years farmed accounts for the farming experience a producer has. More experience is expected to have a positive influence on technology adoption as experienced producers understand the economic benefit of being early adopters (Fernandez-Cornejo *et al.*,

2001). The number of hours worked off-farm is included to account for the effect of employment outside farm on the adoption of cover crops. The influence of this variable in technology adoption of cover crop is ambiguous because it might increase the adoption as producers will have more money from off-farm work which might act as cushion for trying new technology (Paudel *et al.*, 2009). At the same time, it might also have a negative influence because working off-farm gives producers less time to work on cover crops, as indicated by Goodwin and Mishra (2004). The effect of higher education is accounted for by introducing a dummy variable, college. College education is expected to have a positive influence on the adoption of cover crops because higher education increases the ability of the producers to use and benefit from new complex technologies (Barrett et al., 2004; Barham et al. 2004).

Acres Farmed is included as the measure of farm size. The larger the farm, the more likely farmers are to adopt new technology. This continuous variable is expected to have a positive influence on the adoption of cover crops (Neill and Lee, (1999); Bergtold (2007)). Proportion of land owned is included in the model to account for the role of land ownership in the adoption of cover crops. Proportion of land owned is expected to positively affect the adoption of cover crops as per Rahm and Huffman (1984). Croplive is a dummy variable representing the producers who both grow crops and raise livestock, and is expected to have a positive effect in the adoption of cover crops. Extra economic benefits can be achieved by using cover crops for livestock grazing (Lesoing *et al.*, 1997). Cornsoy accounts for the producers growing either corn or soybean, which are the major crops for the Corn-Belt area. The effect of cornsoy is not clear, but is very important to look at, since they are the main crops in the study region. Smallgrain is another dummy variable to capture the effect of growing small grains like oats and wheat in the adoption of cover crops by Corn-Belt producers.

Sources from which producers get information about cover crop use and management are represented in the model in the form of three dummy variables representing local cooperatives, other producers, and university extension programs. All of these sources are expected to have positive effects. The effect of location on the adoption decision of cover crops is accounted for by using three dummy variables, each representing Illinois, Indiana and Minnesota respectively. For this study, Iowa is considered as a base state.

## 4.4. Model Results

To analyze the research question two models were considered. The first was a multinomial logit and the second one was a logit regression model.

### 4.4.1 Multinomial Logit Model Result

For the multinomial logit, the producers were divided into three groups; those who never used cover crops, those who had used cover crops in the past (before 5 years) but currently do not and those who currently use cover crops (within the last 5 years). A multinomial logit was run with the dependent variable (producers) taking the value of 1 if they never used cover crops, 2 if they had used cover crops in the past (5 years ago or more), and 3 if they had used cover crops within past 5 years. Results for multinomial logit regression with base as "never a cover crop user" and "cover crop user in the past" can be found in Appendix F Table F1 and Appendix G Table G1 respectively.

Multinomial logit regression is based on the assumption of independence of irrelevant alternatives (IIA). This means that the values of the estimator do not depend on the number of alternatives. One method for testing for IIA is the Hausmann test. Results from this test were inconclusive. However, the Suest (Seemingly Unrelated Estimation) (Stata Manual, 2005), which is more generalized test compared to the Hausman test, suggested IIA was violated. Hence, it

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was concluded that the multinomial logit was not a good model for this analysis. The results for Hausman and Suest tests can be found in Appendix F and Appendix G.

### 4.4.2. Logit Model Result

Two separate logit models are run to analyze the factors associated with the use of cover crops. The first equation deals with producers who have used cover crops, in the past or at present, and the second equation deals with producers who have used cover crops within the past five years. The second equation will provide a basis for seeing if there has been any change in producers' perceptions towards growing cover crops in recent years.

The log likelihood test for the first regression (Table 4.4) suggested that the estimated model has a good fit, with a statistically significant $Chi^2$ score of 160.61 (P = 0.0000). This indicates a strong relationship between a responding producers' probability of adopting cover crops and the explanatory variables. All of the explanatory variables had the expected signs. Among the regressors included in the model, total acres farmed, proportion of land owned, croplive, cornsoy, smallgrain, cooperatives, farmers, University extension, Illinois and Indiana were statistically significant, whereas yearsfarming, hrsweek, Minnesota, and college were statistically not significant.

Table 4.4 presents the regression coefficients for logit regression in equation 1. The coefficients of the logit regression are difficult to interpret, so either odds ratio or marginal effects are used to interpret the effect of the independent variable on the dependent variable. The odds ratio gives a precise measure of the effect of each of the variables on the probability of adoption in logistic regressions (Bartoloni *et al.*, 2001). The odds ratio is defined as ratio of the odds of an event occurring in one group (producers using cover crops) to the odds of it occurring in another group (producers not using cover crops). The coefficients of the logit regression indicate that all of the variables included in the analysis have positive effect on the adoption of

cover crops, which was as expected. Among them, YearsFarming, Hrsweek, Minnesota, and College were not found to have a statistically significant effect on the adoption of cover crops.

**Table 4.4: Logit Regression (Ever Planted Cover Crops)**

| EverPlantedCC | Coef. | Std. Err. | Z | P>\|z\| |
|---|---|---|---|---|
| YearsFarming | 0.00556 | 0.00869 | 0.64000 | 0.52200 |
| Hrsweek | 0.00244 | 0.00576 | 0.42000 | 0.67200 |
| Illinois* | 0.94097** | 0.29575 | 3.18000 | 0.00100 |
| Indiana* | 1.05920** | 0.28964 | 3.66000 | 0.00000 |
| Minnesota* | 0.33275 | 0.30132 | 1.10000 | 0.26900 |
| College* | 0.33389 | 0.22154 | 1.51000 | 0.13200 |
| AcresFarmed | 0.00025** | 0.00010 | 2.45000 | 0.01400 |
| PropOwned | 0.84873** | 0.30657 | 2.77000 | 0.00600 |
| CropLive* | 0.46817** | 0.20414 | 2.29000 | 0.02200 |
| Cornsoy* | 1.02655* | 0.61224 | 1.68000 | 0.09400 |
| Smallgrain* | 0.58348** | 0.20782 | 2.81000 | 0.00500 |
| Co-op* | 0.95508** | 0.25514 | 3.74000 | 0.00000 |
| Farmers* | 0.88306** | 0.21209 | 4.16000 | 0.00000 |
| Extension* | 0.80284** | 0.20067 | 4.00000 | 0.00000 |
| _cons | -5.21382** | 0.77119 | -6.76000 | 0.00000 |

** and * indicate significance at 5% and 10% level of confidence, respectively
Number of obs = 874, LR chi$^2$ (14) = 160.61, Prob > chi$^2$ = 0.0000, Log likelihood = -351.72838

Table 4.5 presents the marginal effects associated with each of the explanatory variables. Marginal effect can be defined as the effect of a unit change of the independent on the dependent variable. In case of dummy variables, marginal effect is the difference in the dependent variable when the dummy changes from 0 to 1. Estimates indicate that the probability that a producer in Illinois and Indiana adopts cover crop use is, respectively, 0.14 and 0.16 more compared to a producer in Iowa. With every 1,000 acres increase in the total land farmed by the producers, the

probability of using cover crops increases by 0.03. This result was according to expectation, and

the positive relation might be because, among other reasons, cover crop use in larger area might

significantly lower the fertilizer use, lowering the overall cost for a producer having larger farms.

The marginal effect estimates also suggest that if a producer both grows crops and raises

livestock, the probability that he will use cover crops increases by 0.06 compared to the

producers who plant crop only. This may be due to the fact that cover crops may also be used for

animal feed. The probability that a producer growing either corn or soybean uses cover crops is

0.09 more compared to those who do not grow either of the two.

**Table 4.5: Marginal Effects (Ever Planted Cover Crops)**
y = Pr (q26plantedcc) (predict)
$\quad$ = 0.1462873

| Variable | dy/dx | Std. Err. | Z | P > \|z\| | X (Mean) |
|---|---|---|---|---|---|
| YearsFarming | 0.00069 | 0.00109 | 0.64000 | 0.52300 | 32.09270 |
| HrsWeek | 0.00031 | 0.00072 | 0.42000 | 0.67200 | 11.49080 |
| Illinois* | 0.13998** | 0.04996 | 2.80000 | 0.00500 | 0.22998 |
| Indiana* | 0.16068** | 0.05051 | 3.18000 | 0.00100 | 0.23112 |
| Minnesota* | 0.04402 | 0.04195 | 1.05000 | 0.29400 | 0.25515 |
| College* | 0.04405 | 0.03078 | 1.43000 | 0.15200 | 0.26888 |
| AcresFarmed | 0.00003** | 0.00001 | 2.45000 | 0.01400 | 813.07200 |
| PropOwned | 0.10600** | 0.03757 | 2.82000 | 0.00500 | 0.54257 |
| CropLive* | 0.06066** | 0.02710 | 2.23000 | 0.02600 | 0.41076 |
| Cornsoy* | 0.09104** | 0.03614 | 2.52000 | 0.01200 | 0.96453 |
| Smallgrain* | 0.07975** | 0.03080 | 2.59000 | 0.01000 | 0.28261 |
| Co-op* | 0.15052** | 0.04846 | 3.11000 | 0.00200 | 0.13387 |
| Farmers* | 0.12677** | 0.03419 | 3.71000 | 0.00000 | 0.27574 |
| Extension* | 0.11358** | 0.03141 | 3.62000 | 0.00000 | 0.28032 |

(*) dy/dx is for discrete change of dummy variable from 0 to 1
** and * indicate significance at 5% and 10% level of confidence, respectively

Results also indicate that the probability of a producer who grows either oats or wheat of adopting cover crops is 0.08 more compared to those who do not grow either of the two. All the sources of information regarding cover crop use show positive effect on actual use of cover crops by the producers. The probabilities of producers getting information about cover crops use and management from local cooperatives, other producers, and University extension of adopting cover crops are, respectively, 0.15, 0.13, and 0.11 more compared to those who do not get information from these sources. This may also suggest that local co-operatives are more effective in disseminating information regarding cover crop use and management.

**Table 4.6: Logit Regression (Past Five Years)**

| Past5yrs | Coef. | Std. Err. | z | P>|z| |
|---|---|---|---|---|
| YearsFarming | 0.00164 | 0.01007 | 0.16000 | 0.87000 |
| Hrsweek | 0.00057 | 0.00687 | 0.08000 | 0.93400 |
| Illinois* | 1.24463** | 0.34011 | 3.66000 | 0.00000 |
| Indiana* | 0.74041** | 0.35088 | 2.11000 | 0.03500 |
| Minnesota* | 0.26733 | 0.35915 | 0.74000 | 0.45700 |
| College* | 0.18832 | 0.26113 | 0.72000 | 0.47100 |
| AcresFarmed | 0.00036** | 0.00011 | 3.26000 | 0.00100 |
| PropOwned | 0.67117* | 0.35558 | 1.89000 | 0.05900 |
| CropLive* | 1.00736** | 0.24323 | 4.14000 | 0.00000 |
| Cornsoy* | 0.17023 | 0.60934 | 0.28000 | 0.78000 |
| Smallgrain* | 0.57810** | 0.23670 | 2.44000 | 0.01500 |
| Co-op* | 1.14926** | 0.28042 | 4.10000 | 0.00000 |
| Farmers* | 0.85767** | 0.25034 | 3.43000 | 0.00100 |
| Extension* | 0.29689 | 0.24247 | 1.22000 | 0.22100 |
| _cons | -4.88974** | 0.80494 | -6.70000 | 0.00000 |

** and * indicate significance at 5% and 10% level of confidence, respectively
Number of obs = 870, LR chi$^2$ (14) = 124.66, Prob > chi$^2$ = 0.0000, Log likelihood = -271.72899

The log likelihood test for the second model suggests that it is a good fit, with a statistically significant (1% level) score of 124.66. This indicates that there is a strong relationship between a responding producers' probability of adopting cover crops (in past five years) and the independent, explanatory variables. Results in table 4.6 show the estimated coefficients from the logit regression. Almost all of the independent variables show similar effects compared to the first regression, though in varying degrees. There are two notable exceptions. Growing corn or soybean and University extension as a source of information are not statistically significant. Another difference that was noted is the statistical significance of proportion of land owned being significant at 5% level in the first model (ever using cover crops) to being significant only at 10% level in the second model (using cover crops in the past five years).

Table 4.7 contains details about the marginal effects for the cover crop user in the past five years. All the other variables except those mentioned above differed in the effect in cover crop use in degree only. Producers in Illinois were still more likely to use cover crops compared to those in Iowa, though the probability associated with it decreased. The probability that producers raising both crops and livestock use cover crops increased in the past five years by 0.03 while the same for producers growing wheat or oat decreased by 0.03. The most important difference, perhaps, is the difference in the probabilities associated with the sources providing information about cover crop use and management. Results indicate that the marginal probabilities associated with use of cover crops for producers getting information from local co-operatives and other producers are, respectively, 0.13 and 0.08. Both of these figures, though positive are less than those in the first case. Combined with the fact that University extension is statistically not significant, it may indicate that the overall information sources were less effective in the past five years compared to the whole time period.

**Table 4.7: Marginal Effects (Past Five Years)**

y = Pr (q28apast5yrs) (predict) = 0.08474469

| Variable | dy/dx | Std. Err. | Z | P > \|z\| | X (Mean) |
|---|---|---|---|---|---|
| Years | 0.00013 | 0.00078 | 0.16 | 0.870 | 32.11260 |
| HrsWeek | 0.00004 | 0.00053 | 0.08 | 0.934 | 11.54370 |
| Illinois* | 0.12947** | 0.04389 | 2.95 | 0.003 | 0.22989 |
| Indiana* | 0.06823* | 0.03750 | 1.82 | 0.069 | 0.23103 |
| Minnesota* | 0.02192 | 0.03101 | 0.71 | 0.480 | 0.25402 |
| College* | 0.01515 | 0.02177 | 0.70 | 0.486 | 0.26897 |
| AcresFarmed | 0.00003** | 0.00001 | 3.28 | 0.001 | 811.82200 |
| PropOwned | 0.05206* | 0.02725 | 1.19 | 0.056 | 0.54262 |
| CropLive* | 0.08583** | 0.02232 | 3.85 | 0.000 | 0.41149 |
| Cornsoy* | 0.01237 | 0.04140 | 0.30 | 0.765 | 0.96437 |
| Smallgrain* | 0.05007** | 0.02282 | 2.19 | 0.028 | 0.28161 |
| Co-op* | 0.12673** | 0.04104 | 3.09 | 0.002 | 0.13448 |
| Farmers* | 0.07881** | 0.02679 | 2.94 | 0.003 | 0.27701 |
| Extension* | 0.02436 | 0.02098 | 1.16 | 0.246 | 0.27816 |

(*) dy/dx  is for discrete change of dummy variable from 0 to 1

** and * indicate significance at 5% and 10% level of confidence, respectively

# CHAPTER 5

## SUMMARY AND CONCLUSIONS

### 5.1. Summary

Adoption of cover crops in the production system is important because of the role they play in protecting soil, increasing soil fertility and tilth as well as potentially boosting crop yields and improving water quality. Intensive agricultural practices commonly used in today's farms often lead to degradation of soil quality. Excessive plowing leads to decreased binding between soil particles, which makes the soil susceptible to wind and water erosion. Also, chemical fertilizers tend to leach into the ground water system, causing environmental damage. Cover crops not only help in improving the physical properties of soil, but they can also be used as nutrient management tools that potentially create economic benefits.

Despite the widely recognized advantages of cover crops, they have not been adopted widely. This study focused on the factors that affect the adoption of cover crops by producers in four Corn-Belt states, Illinois, Indiana, Iowa and Minnesota.

The objectives of the study were to:

a. Determine which factors (demographic, socio-economic, and farm characteristics) significantly influence the adoption decision for cover crops by producers in the Corn-Belt area.

b. Determine the marginal effects, for those producers who use cover crops, of the factors significantly affecting the cover crop adoption decision.

Data from a survey administered in 2006 by Singer *et al.* were used for the analysis to fulfill the objectives of the research. Various descriptive statistics were used to describe the

characteristics of the sample population, and logistic regression was carried out to determine the impact of the factors associated with the use of cover crops.

While Singer *et. al.* have four regressions for each of the four states, this study took a slightly different approach and represented Indiana, Illinois, and Minnesota with a dummy variable each, Iowa being the base state, in a single regression. With this setup, two different scenarios were studied; the first involving producers who had ever used a cover crop and the second involving only the producers who used cover crops in the past five years. The results of the first analysis indicated that total number of acres farmed, having both crops and livestock, growing small grains like oats and wheat, growing both corn and/or soybeans, availability of different sources on information about cover crops (local cooperatives, other farmers and university extension services) were statistically significant factors affecting the use of cover crops. Among the four Midwestern states included in the study, Indiana and Illinois were found to significantly differ from Iowa in terms of cover crop use, whereas Minnesota did not differ significantly.

For the most part, the results for the second model analyzed were similar to those of the first model. The expectations were that University extension service and growing corn or soybean were statistically not significant factors influencing cover crop adoption in the past five years.

## 5.2. Conclusions

Data from the survey suggest that the average acres farmed for producers that have used cover crops is larger than that of producers who have never used cover crops. Also, the result of the regressions suggests that producers with larger acreage farmed are more inclined towards using cover crops. This may be due to the fact that farmers with larger holdings, and hence higher income, can afford to take the risk of adopting a "new" technology. Also, planting cover

crops over larger areas may significantly lower fertilizer costs and hence the overall cost of production. This outcome may suggest that future plans for cover crop extension should focus more towards farmers with larger acreage.

Producers raising both crops and livestock are more likely to use cover crops in comparison to those growing crops only. This may be due to the fact that the cover crops may also be used as feed for livestock, instead of being incorporated in the soil. Similarly, producers growing small grains like wheat or oat are also more likely to grow cover crops.

For the second scenario, CornSoy was found to be statistically not significant, meaning that either growing corn or soybean, which are two major crops of the Corn Belt, did not have significant effect in the adoption of cover crops in the past 5 years. Cost of production for corn has been increasing, mainly due to increasing cost of nitrogenous fertilizers. USDA data shows that the average price of nitrogenous fertilizers has almost doubled from 2000 to 2005 (ERS/USDA, 2010). Increased fertilizer prices may have shrunk the profit margin of the producer, making the planting of cover crops less cost effective. This research gives detailed study of crops in the dataset by dividing it into cash crops (corn and/or soybean) and small grains (oats and/or wheat) and their significance compared to number of crops in Singer *et al.* (2007).

Comparison of the marginal effects of the two models for the three sources of information regarding cover crops (cooperatives, other farmers and university extension) have all decreased in the past five years compared to the overall period. University extension was not a statistically significant source of information in the past five years. This suggests that the information sources have been relatively less informative about cover crops in the past five years, and that perhaps University extension services in the Midwestern states are not the prominent source of information about cover crops.

**5.3. Limitations of the Thesis**

As with many studies, data were a limiting factor in the analysis. Since the questionnaire used to gather the data used for the analysis was not specifically designed to meet the objectives of this study, the data did not provide all the information we would have liked. Questions regarding cost of cover crops, amount of fertilizer used, and perceived environmental benefits from cover crop would have provided more useful information regarding cover crop adoption and use.

**5.4. Probable Further Research**

Since most of the benefits of cover crops are observed on the long run, a longitudinal study over a number of years would help provide more insights in the field. Moreover, both economical and environmental benefits of cover crops could be studied simultaneously, which would provide a broader view on the overall benefits of cover crops.

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# APPENDIX A: SURVEY QUESTIONNAIRE

## A Survey of Farming Practices and Cover Crop Use
### Iowa State University

For each question that follows, please circle the number that best represents your answer.

## **Background**

1a.  This year, in 2006, are you farming full-time, part-time, or not at all?
1 = Farming full-time
2 = Farming part-time
3 = Do not farm at all　　　　⟶　　b. If not at all, have you farmed in the last 5 years?
　　　　　　　　　　　　　　　　1 = Yes  (Please continue)
　　　　　　　　　　　　　　　　2 = No   (Please return the survey in the envelope provided.)

2.  About how many years have you been farming (in charge of the operation)? _____ years

3a.  Are you also currently employed off the farm?
1 = Yes　　　b.  If yes, how many hours per week do you work off the farm?_____ hrs/week
2 = No

4.  What county do you live in?  _____ County

5.  What is your current age? _____ years

6.  Are you male or female?
　　　1 = Male
　　　2 = Female

7.  What is the highest level of education you have completed?

　　　1 = Eleventh grade or less
　　　2 = High School (includes GED)
　　　3 = Vocational or technical diploma/certificate
　　　4 = Some college but no Bachelor's Degree
　　　5 = B.A., B.S., or equivalent
　　　6 = Graduate Degree, Master's, Ph.D., M.D., etc.

8. We would like to know the approximate size of your farm.

　　　a.  How many acres of tillable farmland are you currently farming? _____ acres farmed

　　　b.  How many of those acres do you **own**? _____ acres owned

　　　c.  How many of those acres do you **rent**? _____ acres rented

**Farming practices**

9. Do you raise crops, livestock, or both?

       1 = Crops only
       2 = Livestock only   [If you do not raise any crops, go to Q11 below.]
       3 = Both crops and livestock

10. Are you growing any of the following crops in 2006? If yes, please record the number of acres.

| Type of crop | Growing in 2006? | Number of Acres in 2006 |
|---|---|---|
| a. Corn for grain or silage | 1 = Yes<br>2 = No | |
| b. Corn for seed | 1 = Yes<br>2 = No | |
| c. Sweet corn | 1 = Yes<br>2 = No | |
| d. Soybean | 1 = Yes<br>2 = No | |
| e. Oats | 1 = Yes<br>2 = No | |
| f. Wheat | 1 = Yes<br>2 = No | |
| g. Hay | 1 = Yes<br>2 = No | |
| h. Other crops (Describe below.)<br>_____ | 1 = Yes<br>2 = No | |

11. Do you currently raise the following types of livestock? If yes, please record the number of head raised in the past year.

| Type of livestock | Raising in 2006? | Number of head |
|---|---|---|
| a. Dairy cattle | 1 = Yes<br>2 = No | |
| b. Beef cattle | 1 = Yes<br>2 = No | |
| c. Hogs | 1 = Yes<br>2 = No | |
| d. Poultry | 1 = Yes<br>2 = No | |
| e. Other livestock (Describe below.)<br>_____ | 1 = Yes<br>2 = No | |

12. Do you farm any land that is certified organic?

        1 = Yes
        2 = No

13. As of January 1, 2006, was any of the land that you farm in a government conservation program, like the CRP, WRP, or EQIP?

        1 = Yes
        2 = No

14a. Have you implemented other conservation practices on your farm, such as conservation tillage, spring vs. fall nitrogen application, waterways, etc.?

  1 = Yes    b. If yes, have you received any cost sharing incentives or income for
  2 = No     these conservation practices?

                                 1 = Yes
                                 2 = No

c. If yes, would you have adopted these practices **without** cost sharing incentives or income?

        1 = Yes
        2 = No

**Cover crop use**

Cover crops are defined as grasses, legumes or small grains **grown between regular grain crop production periods** for the purpose of protecting and improving the soil. These crops are usually planted after harvest of the regular grain crop in the fall and killed before planting the next one in the spring.

15. How familiar are you with using cover crops in this way?

| Not at all familiar | | | | Very Familiar |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

16. Do you think you have enough information about cover crops to make decisions about cover crop selection, use, and management?

1 = Yes
2 = No

17. What kind of information is needed to make decisions about cover crop selection, use, and management?

 

 

 

18.  Have you received information about cover crop selection, use, or management from any of the following sources?  If yes, was the information you received helpful?

| Sources of information | Received cover crop information? | If yes, was the information helpful? |
|---|---|---|
| a.  Local Co-op | 1 = Yes<br>2 = No | 1 = Yes<br>2 = No |
| b.  Other farmers | 1 = Yes<br>2 = No | 1 = Yes<br>2 = No |
| c.  Agribusinesses, such as seed or chemical companies | 1 = Yes<br>2 = No | 1 = Yes<br>2 = No |
| d.  University Extension | 1 = Yes<br>2 = No | 1 = Yes<br>2 = No |
| e.  National Resources Conservation Services (NRCS) | 1 = Yes<br>2 = No | 1 = Yes<br>2 = No |
| f.  Soil and Water Conservation District (SWCD) | 1 = Yes<br>2 = No | 1 = Yes<br>2 = No |
| g.  Agriculture Research Service (ARS) | 1 = Yes<br>2 = No | 1 = Yes<br>2 = No |
| h.  Any other sources of cover crop information? (Describe below.) | 1= Yes<br>2 = No | 1= Yes<br>2 = No |

19.  Some people plant cover crops as soil cover to protect and improve the soil.  What would you say are the advantages of using cover crops like this?    *(Circle all that apply.)*

       1 = reduces soil erosion
       2 = increases water infiltration
       3 = decreases runoff
       4 = increases organic matter in soil
       5 = reduces soil compaction
       6 = suppresses weeds
       7 = increases yield
       8 = lowers pest incidence
       9 = other advantages (Please describe: _____ )

20.  What would be the **most** per acre that you would be **willing to spend** to plant cover crops?
$ _____ per acre

21.  If cost sharing was available, would you use cover crops?
       1 = Yes
       2 = No

22.  What would be the **minimum payment** you would need **to receive** per acre to plant a cover crop?
$ _____ per acre


23.  Do you have a grain drill or other equipment necessary to plant cover crops?

    1 = Yes
    2 = No


24.  Would you be willing to use cover crops if you could hire them custom planted?

    1 = Yes
    2 = No

25.  If you were to plant cover crops, what plant characteristics would you desire?  *(Circle all that apply.)*

    1 = Winterkill
    2 = Fall residue cover
    3 = Spring residue cover
    4 = Nitrogen fixation
    5 = Something else  (Please describe: _____ )


26.  **Have you ever planted cover crops between the growing seasons of grain crops?**

    1 = Yes        [IF YES, GO TO "Cover Crop Experience," NEXT PAGE.]
    2 = No


27.  What are the main reasons you have never planted cover crops?  *(Circle all that apply.)*

    1 = invasive weeds are hard to control
    2 = too much time involved
    3 = already use no till practices
    4 = too costly
    5 = cover crops attract unwanted pests
    6 = I don't have a runoff problem
    7 = cover crops reduce crop yield
    8 = just haven't gotten around to it
    9 = too dry here, cover crops take water from cash crop
    10 = cover crops take nutrients (nitrogen) from cash crop
    11 = don't know enough about them to know if it is right for my farm
    12 = not a land owner (rent farm land)
    13 = other reasons  (Please describe: _____ )


*If you have <u>never planted cover crops</u> between regular grain crop seasons, you may stop here.  Please return this survey in the postage-paid envelope provided.  Thank you very much!*

*If you <u>have</u> planted cover crops between regular grain crop seasons, please continue to the next page. Thank you!*

**Cover Crop Experience**

28a.  Have you planted cover crops in the past five years?

       1 = Yes        [Go to Question 29 below.]
       2 = No

b.  If no, why did you stop planting cover crops?  *(Circle all that apply.)*

            1 = invasive weeds are hard to control
            2 = too much time involved
            3 = too costly
            4 = cover crops attracted unwanted pests
            5 = I don't have a runoff problem
            6 = cover crops reduced crop yield
            7 = too dry here; cover crops take water from cash crop
            8 = cover crops take nutrients (nitrogen) from cash crop
            9 = not a land owner (rents farm land)
            10 = other reasons  (Please describe:_____ )

29.  Which of the following have you planted as a cover crop between growing seasons?  Please record the seeding rate and seed cost per acre for each of the cover crops you have used.

| Cover crops | Used as a cover crop? | Seeding rate | Seed cost per acre |
|---|---|---|---|
| a.  Winter rye | 1 = Yes<br>2 = No | _____ bu/acre | $ _____ /acre |
| b.  Ryegrass | 1 = Yes<br>2 = No | _____ bu/acre | $ _____ /acre |
| c.  Oats | 1 = Yes<br>2 = No | _____ bu/acre | $ _____ /acre |
| d.  Winter wheat | 1 = Yes<br>2 = No | _____ bu/acre | $ _____ /acre |
| e.  Winter triticale | 1 = Yes<br>2 = No | _____ bu/acre | $ _____ /acre |
| f.  Red clover | 1 = Yes<br>2 = No | _____ bu/acre | $ _____ /acre |
| g.  Hairy vetch | 1 = Yes<br>2 = No | _____ bu/acre | $ _____ /acre |
| h.  Something else (Describe below.)<br>_____<br>_____ | 1 = Yes<br>2 = No | _____ bu/acre | $ _____ /acre |

| 30  Which cover crop have you usually planted **after corn**? | 31.  Which cover crop have you usually planted **after soybean**? |
|---|---|
| 1 = Winter rye | 1 = Winter rye |
| 2 = Ryegrass | 2 = Ryegrass |
| 3 = Oats | 3 = Oats |
| 4 = Winter wheat | 4 = Winter wheat |
| 5 = Winter triticale | 5 = Winter triticale |
| 6 = Red clover | 6 = Red clover |
| 7 = Hairy vetch | 7 = Hairy vetch |
| 8 = Other:_____ | 8 = Other:_____ |

32.  How many acres did you plant in cover crops last fall (2005)?   _____ acres of cover crops

33.  Do you plant cover crops on rented or owned acres or both?

      1 = Rented acres only
         2 = Owned acres only
         3 = Both rented and owned acres

     34.  What method do you usually use to plant your cover crops?

      1 = Grain drill
         2 = Aerial seeding
         3 = Other method: _____

35.  Do you custom hire your cover crop planting?

      1 = Yes
      2 = No

36.  Where do you get your cover crop seed?

      1 = Local Co-op
         2 = Seed dealer
         3 = Other farmers
         4 = Save own seed from previous year

37.  How do you select your seeding rate?

      1 = Information from the local co-op
         2 = Information from university extension
         3 = Information from other farmers
         4 = Past experience

38a.  Did you ever have to kill a cover crop because it did not winterkill?

      1 = Yes     2 = No

b.  If yes, did you kill off the cover crop with tillage or chemicals?
            1 = Tillage
            2 = Chemicals

c.  How long did you wait after killing the cover crop to plant your cash crop?

1 = Less than 5 days
2 = 6-10 days
3 = 11-15 days
4 = 16-20 days
5 = More than 20 days


39.  Have you experienced an **increase** in corn or soybean crop yield after using a cover crop?

        1 = Yes        Increased _____ bushels/acre using _____ .
        2 = No                                                                                    (cover crop)

40.  Have you experienced a **decrease** in cash crop yield after using a cover crop?

        1 = Yes        Decreased _____ bushels/acre using _____.
        2 = No                                                                                    (cover crop)

41.  Do you harvest your cover crop?

        1 = Yes, harvest cover crop for animal feed
        2 = Yes, harvest cover crop for other uses
        3 = No, do not harvest cover crops

42.  Have you received any cost sharing incentives for using cover crops?

        1 = Yes
        2 = No

43.  Does using cover crops fulfill any requirements for conservation plans on your farm?

        1 = Yes
        2 = No




***Thank you very much for your time and cooperation!  Please return this completed
survey in the postage-paid envelope provided.***

## APPENDIX B: SUMMARY STATISTICS OF ALL THE DATA IN THE SURVEY, PRODUCERS DIVIDED BY WHETHER THEY HAVE EVER USED COVER CROPS OR NOT

| Variable | Never a cover crop user (878) | | | | | Grown cover crop (ever) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | Mean | Std.Dev. | Min | Max | N | Mean | Std.Dev. | Min | Max |
| Farmedlast5yrs | 878 | 7.70 | 1.42 | 1 | 8 | 201 | 7.76 | 1.29 | 1 | 8 |
| YearsFarming | 863 | 32.43 | 12.61 | 1 | 66 | 196 | 34.13 | 13.39 | 4 | 70 |
| Employed | 871 | 0.31 | 0.46 | 0 | 1 | 200 | 0.28 | 0.45 | 0 | 1 |
| HrsWeek | 861 | 11.23 | 18.90 | 0 | 80 | 197 | 10.07 | 17.84 | 0 | 60 |
| State | 878 | 2.59 | 1.10 | 1 | 4 | 201 | 2.31 | 1.09 | 1 | 4 |
| Age | 873 | 59.01 | 11.12 | 26 | 96 | 200 | 59.76 | 12.37 | 29 | 88 |
| Gender | 876 | 1.01 | .13 | 1 | 2 | 201 | 1.02 | 0.16 | 1 | 2 |
| Educ | 875 | 3.19 | 1.40 | 1 | 6 | 201 | 3.39 | 1.46 | 1 | 6 |
| AcresFarmed | 870 | 752.10 | 885.19 | 0 | 7,000 | 200 | 906.2 | 1,119.55 | 10 | 7,000 |
| AcresOwned | 866 | 294.50 | 353.09 | 0 | 3,300 | 200 | 401.27 | 447.01 | 0 | 3,000 |
| AcresRent | 863 | 458.04 | 718.99 | 0 | 6,000 | 196 | 514.40 | 879.85 | 0 | 5,500 |
| CropLive | 866 | 1.76 | 0.97 | 1 | 3 | 197 | 2.03 | 1.00 | 1 | 3 |
| Corn | 855 | 0.89 | 0.31 | 0 | 1 | 195 | 0.88 | 0.32 | 0 | 1 |
| CornAcres | 799 | 342.45 | 446.96 | 0 | 3500 | 180 | 370.48 | 575.35 | 0 | 3,700 |
| SeedCorn | 855 | 0.03 | 0.18 | 0 | 1 | 195 | 0.07 | 0.25 | 0 | 1 |
| SeedAcres | 858 | 9.39 | 77.23 | 0 | 1500 | 195 | 10.53 | 56.01 | 0 | 460 |
| SweetCorn | 853 | 0.05 | 0.21 | 0 | 1 | 195 | 0.07 | 0.26 | 0 | 1 |
| SweetAcres | 853 | 2.86 | 25.29 | 0 | 500 | 194 | 2.54 | 22.44 | 0 | 293 |
| Soybean | 855 | 0.91 | 0.28 | 0 | 1 | 195 | 0.90 | 0.30 | 0 | 1 |
| SoyAcres | 780 | 332.63 | 426.90 | 0 | 4370 | 173 | 332.60 | 440.49 | 0 | 3,300 |
| Oats | 848 | 0.10 | 0.30 | 0 | 1 | 194 | 0.13 | 0.34 | 0 | 1 |
| OatsAcres | 849 | 1.70 | 7.07 | 0 | 74 | 193 | 3.48 | 15.41 | 0 | 170 |
| Wheat | 852 | 0.15 | 0.36 | 0 | 1 | 195 | 0.34 | 0.48 | 0 | 1 |
| WheatAcres | 850 | 20.87 | 122.31 | 0 | 2,500 | 190 | 58.58 | 211.49 | 0 | 1,650 |
| Hay | 850 | 0.33 | 0.47 | 0 | 1 | 194 | 0.51 | 0.50 | 0 | 1 |
| HayAcres | 820 | 14.69 | 49.82 | 0 | 900 | 181 | 27.38 | 56.47 | 0 | 350 |
| Other | 855 | 0.50 | 0.22 | 0 | 1 | 194 | 0.21 | 0.41 | 0 | 1 |
| OtherAcres | 858 | 17.06 | 148.13 | 0 | 2,500 | 192 | 32.39 | 178.00 | 0 | 2,300 |
| Dairy | 332 | 0.09 | 0.29 | 0 | 1 | 102 | 0.05 | 0.22 | 0 | 1 |
| HeadCount | 863 | 3.16 | 24.66 | 0 | 300 | 197 | 6.51 | 53.04 | 0 | 650 |
| Cattle | 333 | 0.71 | 0.45 | 0 | 1 | 102 | 0.80 | 0.40 | 0 | 1 |
| HeadCount | 840 | 31.26 | 227.29 | 0 | 5,028 | 191 | 42 | 115.52 | 0 | 999 |
| Hogs | 333 | 0.24 | 0.43 | 0 | 1 | 102 | 0.20 | 0.40 | 0 | 1 |
| HeadCount | 859 | 382.11 | 2,452.67 | 0 | 50,000 | 197 | 198.55 | 1,351.30 | 0 | 18,000 |
| Poultry | 333 | 0.05 | 0.22 | 0 | 1 | 101 | 0.06 | 0.24 | 0 | 1 |
| HeadCount | 865 | 653.77 | 12,377.69 | 0 | 5,40,000 | 195 | 513.69 | 7,161.09 | 0 | 100,000 |
| Other | 333 | 0.16 | 0.37 | 0 | 1 | 102 | 0.12 | 0.32 | 0 | 1 |
| HeadCount | 861 | 25.21 | 614.55 | 0 | 18,000 | 197 | 5.52 | 29.46 | 0 | 205 |
| LandOrganic | 868 | 0.003 | 0.06 | 0 | 1 | 196 | 0.02 | 0.14 | 0 | 1 |
| ConservProg | 862 | 0.42 | 0.49 | 0 | 1 | 196 | 0.45 | 0.50 | 0 | 1 |
| Practices | 863 | 0.78 | 0.41 | 0 | 1 | 196 | 0.85 | 0.36 | 0 | 1 |
| Incentives | 668 | 0.42 | 0.49 | 0 | 1 | 164 | 0.46 | 0.50 | 0 | 1 |
| Adopted | 266 | 0.56 | 0.50 | 0 | 1 | 72 | 0.60 | 0.49 | 0 | 1 |
| Familiar | 847 | 2.59 | 1.27 | 1 | 5 | 194 | 4 | 1.08 | 1 | 5 |
| Informed | 848 | 0.50 | 0.50 | 0 | 1 | 193 | 0.79 | 0.41 | 0 | 1 |
| Info1 | 868 | 0.76 | 1.48 | 0 | 7 | 197 | 1.02 | 1.67 | 0 | 7 |

**APPENDIX B (CONTD.): SUMMARY STATISTICS OF ALL THE DATA IN THE SURVEY, PRODUCERS DIVIDED BY WHETHER THEY HAVE EVER USED COVER CROPS OR NOT**

| Variable | Never a cover crop user (878) | | | | | Grown cover crop (ever) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | Mean | Std.Dev. | Min | Max | N | Mean | Std.Dev. | Min | Max |
| Info2 | 724 | 0.51 | 1.43 | 0 | 7 | 154 | 0.73 | 1.73 | 0 | 6 |
| Co-op | 771 | 0.10 | 0.30 | 0 | 1 | 187 | 0.30 | 0.46 | 0 | 1 |
| Co-opHelpful | 71 | 0.97 | 0.17 | 0 | 1 | 52 | 1 | 0 | 1 | 1 |
| Farmers | 768 | 0.21 | 0.41 | 0 | 1 | 186 | 0.53 | 0.50 | 0 | 1 |
| FarmerHelpful | 151 | 0.92 | 0.27 | 0 | 1 | 91 | 0.98 | 0.15 | 0 | 1 |
| Agribu | 769 | 0.12 | 0.32 | 0 | 1 | 185 | 0.34 | 0.48 | 0 | 1 |
| AgribuHelpful | 85 | 0.95 | 0.21 | 0 | 1 | 56 | 0.95 | 0.23 | 0 | 1 |
| Extension | 770 | 0.24 | 0.42 | 0 | 1 | 186 | 0.5 | 0.50 | 0 | 1 |
| ExtensiHelpful | 156 | 0.92 | 0.27 | 0 | 1 | 85 | 0.96 | 0.19 | 0 | 1 |
| NRCS | 768 | 0.16 | 0.37 | 0 | 1 | 187 | 0.32 | 0.47 | 0 | 1 |
| NRCSHelpful | 102 | 0.95 | 0.22 | 0 | 1 | 53 | 0.92 | 0.27 | 0 | 1 |
| SWCD | 769 | 0.26 | 0.44 | 0 | 1 | 188 | 0.44 | 0.50 | 0 | 1 |
| SWCDHelpful | 167 | 0.94 | 0.24 | 0 | 1 | 74 | 0.97 | 0.16 | 0 | 1 |
| ARS | 769 | 0.03 | 0.17 | 0 | 1 | 186 | 0.10 | 0.30 | 0 | 1 |
| ARSHelpful | 21 | 0.95 | 0.22 | 0 | 1 | 15 | 1 | 0 | 1 | 1 |
| Other | 772 | 0.09 | 0.29 | 0 | 1 | 186 | 0.13 | 0.34 | 0 | 1 |
| OtherHelpful | 49 | 0.86 | 0.35 | 0 | 1 | 20 | 0.95 | 0.22 | 0 | 1 |
| Erosion | 772 | 0.96 | 0.19 | 0 | 1 | 199 | 0.94 | 0.23 | 0 | 1 |
| Infiltration | 772 | 0.52 | 0.50 | 0 | 1 | 199 | 0.64 | 0.48 | 0 | 1 |
| Runoff | 772 | 0.82 | 0.39 | 0 | 1 | 199 | 0.82 | 0.39 | 0 | 1 |
| OrganicMatter | 772 | 0.73 | 0.44 | 0 | 1 | 199 | 0.81 | 0.39 | 0 | 1 |
| Compaction | 772 | 0.35 | 0.48 | 0 | 1 | 199 | 0.49 | -.50 | 0 | 1 |
| Weeds | 772 | 0.49 | 0.50 | 0 | 1 | 199 | 0.62 | 0.49 | 0 | 1 |
| Yields | 772 | 0.24 | 0.42 | 0 | 1 | 199 | 0.44 | 0.50 | 0 | 1 |
| Pests | 772 | 0.11 | 0.31 | 0 | 1 | 199 | 0.16 | 0.36 | 0 | 1 |
| OtherAdv | 772 | 0.11 | 0.31 | 0 | 1 | 199 | 0.07 | 0.25 | 0 | 1 |
| MostSpend | 487 | 12.34 | 14.76 | 0 | 98 | 158 | 17.09 | 16.13 | 0 | 98 |
| CostSharing | 694 | 0.50 | 0.50 | 0 | 1 | 187 | 0.81 | 0.39 | 0 | 1 |
| MinPayment | 424 | 24.52 | 26.67 | 0 | 98 | 135 | 17.85 | 20.09 | 0 | 98 |
| GrainDrill | 837 | 0.54 | 0.50 | 0 | 1 | 199 | 0.81 | 0.39 | 0 | 1 |
| CustomPlant | 721 | 0.29 | 0.50 | 0 | 1 | 178 | 0.47 | 0.50 | 0 | 1 |
| WinterKill | 651 | 0.33 | 0.47 | 0 | 1 | 185 | 0.26 | 0.44 | 0 | 1 |
| FallResidue | 651 | 0.54 | 0.50 | 0 | 1 | 185 | 0.65 | 0.48 | 0 | 1 |
| SpringResidue | 651 | 0.27 | 0.45 | 0 | 1 | 185 | 0.50 | 0.50 | 0 | 1 |
| NitrogenFix | 651 | 0.65 | 0.48 | 0 | 1 | 185 | 0.63 | 0.48 | 0 | 1 |
| SomethingElse | 651 | 0.02 | 0.15 | 0 | 1 | 185 | 0.11 | 0.31 | 0 | 1 |
| Past5yrsCC | 878 | 0 | 0 | 0 | 0 | 195 | 0.64 | 0.48 | 0 | 1 |
| FullTime | 878 | 0.65 | 0.48 | 0 | 1 | 201 | 0.68 | 0.47 | 0 | 1 |
| PartTime | 878 | 0.31 | 0.46 | 0 | 1 | 201 | 0.29 | 0.45 | 0 | 1 |
| Illinois | 878 | 0.23 | 0.42 | 0 | 1 | 201 | 0.27 | 0.45 | 0 | 1 |
| Indiana | 878 | 0.20 | 0.40 | 0 | 1 | 201 | 0.35 | 0.48 | 0 | 1 |

**APPENDIX B (CONTD.): SUMMARY STATISTICS OF ALL THE DATA IN THE
SURVEY, PRODUCERS DIVIDED BY WHETHER THEY HAVE EVER USED COVER
CROPS OR NOT**

| Variable | Never a cover crop user (878) | | | | | Grown cover crop (ever) (201) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | Mean | Std.Dev. | Min | Max | N | Mean | Std.Dev. | Min | Max |
| Minnesota | 878 | 0.25 | 0.43 | 0 | 1 | 201 | 0.21 | 0.41 | 0 | 1 |
| GTHS | 875 | 0.54 | 0.50 | 0 | 1 | 201 | 0.60 | 0.49 | 0 | 1 |
| College | 875 | 0.23 | 0.42 | 0 | 1 | 201 | 0.29 | 0.45 | 0 | 1 |
| SomeCollege | 875 | 0.42 | 0.49 | 0 | 1 | 201 | 0.50 | 0.50 | 0 | 1 |
| LTHS | 875 | 0.53 | 0.22 | 0 | 1 | 201 | 0.06 | 0.25 | 0 | 1 |
| PropLandOwn | 856 | 0.60 | 0.71 | 0 | 14.2 | 199 | 0.62 | 0.41 | 0 | 3.03 |
| CropOnly | 866 | 0.62 | 0.49 | 0 | 1 | 197 | 0.48 | 0.50 | 0 | 1 |
| CropLive | 866 | 0.38 | 0.48 | 0 | 1 | 197 | 0.51 | 0.50 | 0 | 1 |
| LiveOnly | 866 | 0.01 | 0.09 | 0 | 1 | 197 | 0.10 | 0.10 | 0 | 1 |
| AllCorn | 855 | 0.91 | 0.29 | 0 | 1 | 195 | 0.90 | 0.30 | 0 | 1 |
| SmallGrain | 847 | 0.24 | 0.43 | 0 | 1 | 194 | 0.43 | 0.50 | 0 | 1 |
| CornSoy | 855 | 0.96 | 0.20 | 0 | 1 | 195 | 0.97 | 0.16 | 0 | 1 |
| TotalAcres | 753 | 759.93 | 888.14 | 0 | 7225 | 167 | 884.13 | 1,116.77 | 0 | 7,000 |

# APPENDIX C: SUMMARY STATISTICS OF ALL THE DATA IN THE SURVEY, PRODUCERS DIVIDED BY WHETHER THEY PLANTED COVER CROPS IN THE PAST FIVE YEARS OR NOT

| Variables | Not a cover crop user in the past 5 years | | | | | Cover crop user in the past 5 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | Mean | Std.Dev | Min | Max | N | Mean | Std.Dev. | Min | Max |
| Farmedlast5yrs | 948 | 7.69 | 1.44 | 1 | 8 | 125 | 7.89 | 0.88 | 1 | 8 |
| YearsFarming | 930 | 32.67 | 12.60 | 1 | 66 | 123 | 33.24 | 13.95 | 5 | 70 |
| Employed | 940 | 0.32 | 0.47 | 0 | 1 | 125 | 0.26 | 0.44 | 0 | 1 |
| HrsWeek | 927 | 11.25 | 18.86 | 0 | 80 | 125 | 9.81 | 17.84 | 0 | 60 |
| State | 948 | 2.57 | 1.09 | 1 | 4 | 125 | 2.26 | 1.12 | 1 | 4 |
| Age | 943 | 59.21 | 11.17 | 26 | 96 | 124 | 58.66 | 12.92 | 30 | 87 |
| Gender | 946 | 1.02 | 0.13 | 1 | 2 | 125 | 1.02 | 0.13 | 1 | 2 |
| Educ | 945 | 3.20 | 1.40 | 1 | 6 | 125 | 3.384 | 1.49 | 1 | 6 |
| AcresFarmed | 939 | 751.20 | 880.85 | 0 | 7,000 | 125 | 1,004.4 | 1,255.24 | 10 | 7,000 |
| AcresOwned | 935 | 298.75 | 349.20 | 0 | 3,300 | 125 | 432.43 | 512.90 | 0 | 3,000 |
| AcresRent | 931 | 454.16 | 718.48 | 0 | 6,000 | 122 | 578.28 | 968.53 | 0 | 5,500 |
| CropLive | 935 | 1.75 | 0.96 | 1 | 3 | 124 | 2.24 | 0.97 | 1 | 3 |
| Corn | 922 | 0.89 | 0.31 | 0 | 1 | 124 | 0.87 | 0.34 | 0 | 1 |
| CornAcres | 862 | 344.63 | 447.92 | 0 | 3,500 | 114 | 378.94 | 635.15 | 0 | 3,700 |
| SeedCorn | 922 | 0.04 | 0.19 | 0 | 1 | 124 | 0.05 | 0.22 | 0 | 1 |
| SeedAcres | 926 | 9.71 | 76.50 | 0 | 1,500 | 123 | 6.42 | 40.79 | 0 | 400 |
| SweetCorn | 920 | 0.05 | 0.21 | 0 | 1 | 124 | 0.08 | 0.27 | 0 | 1 |
| SweetAcres | 921 | 2.75 | 24.54 | 0 | 500 | 122 | 3.24 | 27.02 | 0 | 293 |
| Soybean | 922 | 0.91 | 0.28 | 0 | 1 | 124 | 0.90 | 0.31 | 0 | 1 |
| SoyAcres | 840 | 332.51 | 426.78 | 0 | 4,370 | 110 | 333.65 | 451.07 | 0 | 3,300 |
| Oats | 915 | 0.10 | 0.29 | 0 | 1 | 123 | 0.15 | 0.36 | 0 | 1 |
| OatsAcres | 917 | 1.66 | 6.95 | 0 | 74 | 121 | 4.91 | 18.96 | 0 | 170 |
| Wheat | 919 | 0.16 | 0.37 | 0 | 1 | 124 | 0.39 | 0.49 | 0 | 1 |
| WheatAcres | 919 | 20.59 | 118.25 | 0 | 2,500 | 118 | 79.21 | 259.01 | 0 | 1,650 |
| Hay | 916 | 0.33 | 0.47 | 0 | 1 | 124 | 0.60 | 0.49 | 0 | 1 |
| HayAcres | 883 | 14.40 | 48.73 | 0 | 900 | 114 | 34.99 | 60.38 | 0 | 350 |
| Other | 921 | 0.05 | 0.23 | 0 | 1 | 124 | 0.26 | 0.44 | 0 | 1 |
| OtherAcres | 925 | 16.15 | 142.81 | 0 | 2,500 | 121 | 46.60 | 221.35 | 0 | 2,300 |
| Dairy | 356 | 0.09 | 0.28 | 0 | 1 | 77 | 0.06 | 0.25 | 0 | 1 |
| HeadCount | 932 | 3.35 | 23.75 | 0 | 300 | 124 | 10.34 | 66.65 | 0 | 650 |
| Cattle | 357 | 0.72 | 0.45 | 0 | 1 | 77 | 0.81 | 0.40 | 0 | 1 |
| HeadCount | 906 | 29.84 | 219.00 | 0 | 5,028 | 121 | 59.81 | 141.14 | 0 | 999 |
| Hogs | 357 | 0.24 | 0.43 | 0 | 1 | 77 | 0.19 | 0.40 | 0 | 1 |
| HeadCount | 928 | 356.66 | 2,362.06 | 0 | 50,000 | 124 | 293.27 | 1,690.98 | 0 | 18,000 |
| Poultry | 357 | 0.05 | 0.22 | 0 | 1 | 76 | 0.05 | 0.22 | 0 | 1 |
| HeadCount | 934 | 605.52 | 17,685.9 | 0 | 5,40,000 | 122 | 820.49 | 9,053.50 | 0 | 1,00,000 |
| Other | 357 | 0.15 | 0.36 | 0 | 1 | 77 | 0.12 | 0.32 | 0 | 1 |
| HeadCount | 930 | 23.73 | 591.37 | 0 | 18,000 | 124 | 5.81 | 29.39 | 0 | 205 |
| Organic | 937 | 0.003 | 0.06 | 0 | 1 | 123 | 0.03 | 0.18 | 0 | 1 |
| ConservProg | 930 | 0.42 | 0.49 | 0 | 1 | 124 | 0.45 | 0.50 | 0 | 1 |
| Practices | 932 | 0.78 | 0.41 | 0 | 1 | 123 | 0.88 | 0.33 | 0 | 1 |
| Incentives | 725 | 0.42 | 0.49 | 0 | 1 | 105 | 0.45 | 0.50 | 0 | 1 |
| Adopted | 291 | 0.57 | 0.50 | 0 | 1 | 45 | 0.56 | 0.50 | 0 | 1 |
| Familiar | 915 | 2.67 | 1.29 | 1 | 5 | 122 | 4.16 | 1.03 | 1 | 5 |

**APPENDIX C (CONTD.): SUMMARY STATISTICS OF ALL THE DATA IN THE SURVEY, PRODUCERS DIVIDED BY WHETHER THEY PLANTED COVER CROPS IN THE PAST FIVE YEARS OR NOT**

| Variable | Not a cover crop user in the past 5 years | | | | | Cover crop user in the past 5 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | Mean | Std.Dev. | Min | Max | N | Mean | Std.Dev. | Min | Max |
| Informed | 915 | 0.52 | 0.50 | 0 | 1 | 122 | 0.81 | 0.39 | 0 | 1 |
| Info1 | 937 | 0.77 | 1.49 | 0 | 7 | 124 | 1.08 | 1.72 | 0 | 7 |
| Info2 | 779 | 0.50 | 1.43 | 0 | 7 | 96 | 0.92 | 1.91 | 0 | 6 |
| Co-op | 836 | 0.11 | 0.31 | 0 | 1 | 117 | 0.35 | 0.48 | 0 | 1 |
| Co-opHelpful | 83 | 0.23 | 0.42 | 0 | 1 | 40 | 1 | 0 | 1 | 1 |
| OtherFarmers | 832 | 0.23 | 0.42 | 0 | 1 | 117 | 0.56 | 0.50 | 0 | 1 |
| FarmerHelpful | 178 | 0.93 | 0.26 | 0 | 1 | 63 | 0.98 | 0.13 | 0 | 1 |
| Agribu | 833 | 0.13 | 0.34 | 0 | 1 | 116 | 0.36 | 0.48 | 0 | 1 |
| AgribuHelpful | 101 | 0.95 | 0.22 | 0 | 1 | 38 | 0.95 | 0.23 | 0 | 1 |
| Extension | 834 | 0.26 | 0.44 | 0 | 1 | 117 | 0.44 | 0.50 | 0 | 1 |
| ExtensiHelpful | 190 | 0.93 | 0.25 | 0 | 1 | 47 | 0.96 | 0.20 | 0 | 1 |
| NRCS | 833 | 0.18 | 0.38 | 0 | 1 | 117 | 0.31 | 0.46 | 0 | 1 |
| NRCSHelpful | 121 | 0.94 | 0.23 | 0 | 1 | 32 | 0.94 | 0.25 | 0 | 1 |
| SWCD | 835 | 0.28 | 0.45 | 0 | 1 | 117 | 0.43 | 0.50 | 0 | 1 |
| SWCDHelpful | 191 | 0.94 | 0.23 | 0 | 1 | 46 | 0.98 | 0.15 | 0 | 1 |
| ARS | 833 | 0.04 | 0.20 | 0 | 1 | 117 | 0.08 | 0.27 | 0 | 1 |
| ARSHelpful | 29 | 0.97 | 0.19 | 0 | 1 | 7 | 1 | 0 | 1 | 1 |
| Other | 836 | 0.10 | 0.30 | 0 | 1 | 117 | 0.10 | 0.30 | 0 | 1 |
| OtherHelpful | 60 | 0.88 | 0.32 | 0 | 1 | 9 | 0.89 | 0.33 | 0 | 1 |
| Erosion | 842 | 0.96 | 0.20 | 0 | 1 | 123 | 0.95 | 0.22 | 0 | 1 |
| Infiltration | 842 | 0.53 | 0.50 | 0 | 1 | 123 | 0.61 | 0.49 | 0 | 1 |
| Runoff | 842 | 0.82 | 0.39 | 0 | 1 | 123 | 0.81 | 0.39 | 0 | 1 |
| OrganicMatter | 842 | 0.74 | 0.44 | 0 | 1 | 123 | 0.78 | 0.42 | 0 | 1 |
| Compaction | 842 | 0.37 | 0.48 | 0 | 1 | 123 | 0.46 | 0.50 | 0 | 1 |
| Weeds | 842 | 0.50 | 0.50 | 0 | 1 | 123 | 0.66 | 0.48 | 0 | 1 |
| Yields | 842 | 0.25 | 0.43 | 0 | 1 | 123 | 0.46 | 0.50 | 0 | 1 |
| Pests | 842 | 0.11 | 0.31 | 0 | 1 | 123 | 0.16 | 0.37 | 0 | 1 |
| OtherAdv | 842 | 0.03 | 0.17 | 0 | 1 | 123 | 0.06 | 0.23 | 0 | 1 |
| GrainDrill | 905 | 0.55 | 0.50 | 0 | 1 | 125 | 0.86 | 0.35 | 0 | 1 |
| CustomPlant | 783 | 0.31 | 0.46 | 0 | 1 | 111 | 0.48 | 0.50 | 0 | 1 |
| Q25aWinter | 714 | 0.32 | 0.47 | 0 | 1 | 118 | 0.22 | 0.42 | 0 | 1 |
| Q25bFall | 714 | 0.55 | 0.49 | 0 | 1 | 118 | 0.64 | 0.48 | 0 | 1 |
| Q25cSpring | 714 | 0.29 | 0.45 | 0 | 1 | 118 | 0.54 | 0.50 | 0 | 1 |
| Q25dNitrogen | 714 | 0.65 | 0.48 | 0 | 1 | 118 | 0.59 | 0.49 | 0 | 1 |
| Q25eOther | 714 | 0.03 | 0.18 | 0 | 1 | 118 | 0.09 | 0.29 | 0 | 1 |
| PlantedCC | 948 | 0.07 | 0.26 | 0 | 1 | 125 | 1 | 0 | 1 | 1 |
| Rye | 59 | 0.54 | 0.50 | 0 | 1 | 122 | 0.36 | 0.48 | 0 | 1 |
| RyeSeeding | 926 | 0.03 | 0.24 | 0 | 3 | 120 | 0.57 | 0.87 | 0 | 3 |
| RyeCost | 920 | 0.11 | 0.86 | 0 | 10 | 109 | 2.61 | 4.80 | 0 | 20 |
| Ryegrass | 59 | 0.12 | 0.33 | 0 | 1 | 122 | 0.13 | 0.34 | 0 | 1 |
| RyegraSeeding | 932 | 0.003 | 0.07 | 0 | 1.5 | 119 | 0.22 | 1.33 | 0 | 14 |
| RyegraCost | 930 | 0 | 0 | 0 | 0 | 116 | 0.94 | 3.64 | 0 | 25 |
| Oats | 59 | 0.34 | 0.48 | 0 | 1 | 122 | 0.26 | 0.44 | 0 | 1 |
| OatsSeeding | 931 | 0.03 | 0.25 | 0 | 3 | 120 | 0.41 | 0.78 | 0 | 3 |
| OatsCost | 929 | 0.08 | 0.80 | 0 | 14 | 111 | 0.95 | 2.30 | 0 | 10 |
| Wheat | 59 | 0.27 | 0.45 | 0 | 1 | 122 | 0.41 | 0.49 | 0 | 1 |

| Variable | Not a cover crop user in the past 5 years | | | | | Cover crop user in the past 5 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | Mean | Std.Dev. | Min | Max | N | Mean | Std.Dev. | Min | Max |
| WheatSeeding | 931 | 0.02 | 0.18 | 0 | 3 | 117 | 0.57 | 0.82 | 0 | 3 |
| WheatCost | 928 | 0.05 | 0.70 | 0 | 16 | 106 | 3.96 | 7.31 | 0 | 36 |
| Tritcile | 59 | 0.02 | 0.13 | 0 | 1 | 121 | 0.01 | 0.91 | 0 | 1 |
| TriticileSeedin | 937 | 0.001 | 0.05 | 0 | 1.5 | 120 | 0 | 0 | 0 | 0 |
| MostSpend | 534 | 12.70 | 14.87 | 0 | 98 | 105 | 16.95 | 14.65 | 0 | 98 |
| CostSharing | 756 | 0.51 | 0.50 | 0 | 1 | 120 | 0.9 | 0.30 | 0 | 1 |
| MinPayment | 464 | 24.29 | 26.30 | 0 | 98 | 91 | 16.40 | 19.39 | 0 | 98 |
| TiticleCost | 937 | 0.03 | 0.82 | 0 | 25 | 120 | 0 | 0 | 0 | 0 |
| Clover | 59 | 0.34 | 0.48 | 0 | 1 | 122 | 0.22 | 0.42 | 0 | 1 |
| CloverSeeding | 926 | 0.002 | 0.02 | 0 | 0.3 | 117 | 0.15 | 0.79 | 0 | 8 |
| CloverCost | 921 | 0.06 | 1.02 | 0 | 25 | 110 | 2.63 | 10.65 | 0 | 98 |
| Vetch | 59 | 0.07 | 0.25 | 0 | 1 | 122 | 0.06 | 0.23 | 0 | 1 |
| VetchSeeding | 935 | 0.003 | 0.07 | 0 | 1.5 | 121 | 0.02 | 0.11 | 0 | 1 |
| VetchCost | 933 | 0 | 0 | 0 | 0 | 118 | 0.43 | 2.88 | 0 | 25 |
| Other | 59 | 0.08 | 0.28 | 0 | 1 | 122 | 0.12 | 0.33 | 0 | 1 |
| OtherSeeding | 934 | 0.002 | 0.07 | 0 | 2 | 118 | 0.14 | 0.59 | 0 | 5 |
| OtherCost | 933 | 0.01 | 0.33 | 0 | 10 | 117 | 1.36 | 9.35 | 0 | 98 |
| AfterCorn1 | 26 | 2.08 | 1.44 | 1 | 6 | 71 | 2.33 | 1.44 | 1 | 6 |
| AfterCorn2 | 6 | 3.67 | 0.82 | 2 | 4 | 10 | 3.6 | 1.78 | 0 | 6 |
| AfterSoy1 | 35 | 2.4 | 1.68 | 0 | 7 | 83 | 2.63 | 1.36 | 0 | 4 |
| AfterSoy2 | 7 | 5 | 1.63 | 3 | 7 | 13 | 4.84 | 1.14 | 3 | 6 |
| Q32Acresla | 940 | 0.17 | 3.54 | 0 | 100 | 117 | 62.03 | 165.60 | 0 | 1,600 |
| Q33Plant | 46 | 2.22 | 0.59 | 1 | 3 | 120 | 2.31 | 0.72 | 1 | 3 |
| Q34Method | 55 | 1.76 | 1.29 | 1 | 5 | 121 | 1.95 | 1.52 | 1 | 6 |
| Q35Hire | 55 | 0.11 | 0.31 | 0 | 1 | 120 | 0.12 | 0.32 | 0 | 1 |
| Q36aSource | 57 | 0.40 | 0.49 | 0 | 1 | 119 | 0.35 | 0.48 | 0 | 1 |
| Q36bSource | 0 | | | | | 0 | | | | |
| Q36cSource | 57 | 0.21 | 0.41 | 0 | 1 | 119 | 0.17 | 0.38 | 0 | 1 |
| Q36dSource | 57 | 0.25 | 0.43 | 0 | 1 | 119 | 0.20 | 0.40 | 0 | 1 |
| RateCoop | 58 | 0.28 | 0.45 | 0 | 1 | 118 | 0.19 | 0.40 | 0 | 1 |
| RateExtension | 58 | 0.29 | 0.46 | 0 | 1 | 118 | 0.11 | 0.31 | 0 | 1 |
| RateFarmer | 58 | 0.22 | 0.42 | 0 | 1 | 118 | 0.18 | 0.38 | 0 | 1 |
| RateSelf | 58 | 0.62 | 0.49 | 0 | 1 | 118 | 0.70 | 0.46 | 0 | 1 |
| Q38aKill | 57 | 0.65 | 0.48 | 0 | 1 | 122 | 0.68 | 0.47 | 0 | 1 |
| Q38bYesKill | 37 | 1.59 | 0.64 | 1 | 3 | 79 | 1.94 | 0.63 | 1 | 3 |
| Q38cWait | 34 | 2.18 | 1.11 | 1 | 5 | 76 | 2.13 | 1.18 | 1 | 5 |
| Increase | 48 | 0.35 | 0.48 | 0 | 1 | 106 | 0.50 | 0.50 | 0 | 1 |
| IncBushel | 917 | 0.08 | 0.91 | 0 | 15 | 87 | 3.91 | 5.76 | 0 | 20 |
| CCUsed | 11 | 3.54 | 2.16 | 0 | 6 | 35 | 2.94 | 2.13 | 0 | 6 |
| Decrease | 46 | 0.26 | 0.44 | 0 | 1 | 108 | 0.14 | 0.35 | 0 | 1 |
| DecBushel | 921 | 0.12 | 1.34 | 0 | 20 | 100 | 0.78 | 3.66 | 0 | 30 |
| CCUsed | 7 | 2.85 | 1.86 | 1 | 6 | 12 | 2.58 | 1.31 | 1 | 4 |
| Harvest | 58 | 2.43 | 0.84 | 1 | 3 | 122 | 2.33 | 0.90 | 1 | 3 |
| Q42recdinc | 58 | 0.09 | 0.28 | 0 | 1 | 121 | 0.07 | 0.26 | 0 | 1 |
| Fulfill | 55 | 0.2 | 0.40 | 0 | 1 | 118 | 0.52 | 0.50 | 0 | 1 |
| FullTime | 948 | 0.64 | 0.48 | 0 | 1 | 125 | 0.73 | 0.45 | 0 | 1 |

**APPENDIX C (CONTD.): SUMMARY STATISTICS OF ALL THE DATA IN THE SURVEY, PRODUCERS DIVIDED BY WHETHER THEY PLANTED COVER CROPS IN THE PAST FIVE YEARS OR NOT**

| Variable | Not a cover crop user in the past 5 years | | | | | Cover crop user in the past 5 years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | Mean | Std.Dev. | Min | Max | N | Mean | Std.Dev. | Min | Max |
| PartTime | 948 | 0.31 | 0.46 | 0 | 1 | 125 | 0.26 | 0.44 | 0 | 1 |
| Illinois | 948 | 0.23 | 0.42 | 0 | 1 | 125 | 0.32 | 0.47 | 0 | 1 |
| Indiana | 948 | 0.22 | 0.41 | 0 | 1 | 125 | 0.31 | 0.47 | 0 | 1 |
| Minnesota | 948 | 0.25 | 0.43 | 0 | 1 | 125 | 0.21 | 0.41 | 0 | 1 |
| GTHS | 945 | 0.54 | 0.50 | 0 | 1 | 125 | 0.61 | 0.49 | 0 | 1 |
| College | 945 | 0.24 | 0.43 | 0 | 1 | 125 | 0.28 | 0.45 | 0 | 1 |
| SomeCollege | 945 | 0.43 | 0.49 | 0 | 1 | 125 | 0.50 | 0.50 | 0 | 1 |
| LTHS | 945 | 0.05 | 0.22 | 0 | 1 | 125 | 0.08 | 0.27 | 0 | 1 |
| PropLandOwn | 924 | 0.61 | 0.69 | 0 | 14.2 | 125 | 0.59 | 0.41 | 0 | 3.03 |
| CropOnly | 935 | 0.62 | 0.49 | 0 | 1 | 124 | 0.38 | 0.49 | 0 | 1 |
| CropLive | 935 | 0.37 | 0.48 | 0 | 1 | 124 | 0.62 | 0.49 | 0 | 1 |
| LiveOnly | 935 | 0.01 | 0.10 | 0 | 1 | 124 | 0 | 0 | 0 | 0 |
| AllCorn | 922 | 0.91 | 0.29 | 0 | 1 | 124 | 0.88 | 0.33 | 0 | 1 |
| SmallGrain | 914 | 0.25 | 0.43 | 0 | 1 | 123 | 0.50 | 0.50 | 0 | 1 |
| CornSoy | 922 | 0.96 | 0.20 | 0 | 1 | 124 | 0.97 | 0.18 | 0 | 1 |
| TotalAcres | 810 | 762.38 | 888.88 | 0 | 7,225 | 107 | 932.99 | 1,222.15 | 20 | 7,000 |

# APPENDIX D: T-TEST RESULTS

**Table D 1: T-test Results by cover crop user**

| Variables | Cover crop user | | Not a cover crop user | | | |
|---|---|---|---|---|---|---|
| | N | Mean | N | Mean | t-stat | p-value |
| YearsFarming | 196 | 34.13 | 863 | 32.43 | -1.68 | 0.047 |
| AcresFarmed | 200 | 906.2 | 870 | 752.10 | -2.11 | 0.018 |
| PropOwned | 198 | 0.61 | 860 | 0.54 | -2.47 | 0.007 |
| HrsWeek | 197 | 10.07 | 861 | 11.23 | 0.79 | 0.433 |

**Table D 2: T-test Results by cover crop user in the past five years**

| Variables | Cover crop user in the past five years | | Not a cover crop user in the past five years | | | |
|---|---|---|---|---|---|---|
| | N | Mean | N | Mean | t-stat | p-value |
| YearsFarming | 123 | 33.24 | 930 | 32.67 | -0.46 | 0.322 |
| AcresFarmed | 125 | 1,004.40 | 939 | 751.20 | -2.85 | 0.002 |
| PropOwned | 124 | 0.59 | 928 | 0.54 | -1.26 | 0.104 |
| HrsWeek | 125 | 9.81 | 927 | 11.25 | 0.81 | 0.420 |

# APPENDIX E: CORRELATION MATRIX FOR EXPLANATORY VARIABLES USED IN THE MODEL

| | Years Farming | HrsWeek | Illinois | Indiana | Minnesota | College | Acres Farmed | Prop Land | Crop Live | Corn Soy | Small grain | Co-op | Farmers | Extension |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Years Farming | 1.0000 | | | | | | | | | | | | | |
| HrsWeek | -0.2732 | 1.0000 | | | | | | | | | | | | |
| Illinois | -0.0029 | -0.0455 | 1.0000 | | | | | | | | | | | |
| Indiana | 0.0615 | 0.0329 | -0.2987 | 1.0000 | | | | | | | | | | |
| Minnesota | -0.0314 | 0.0541 | -0.3189 | -0.3199 | 1.0000 | | | | | | | | | |
| College | -0.2473 | -0.0044 | 0.0434 | 0.0906 | -0.0818 | 1.0000 | | | | | | | | |
| Acres Farmed | -0.0995 | -0.2748 | 0.0292 | 0.0522 | 0.0467 | 0.1045 | 1.0000 | | | | | | | |
| PropLand | 0.1699 | -0.0528 | -0.0519 | 0.0102 | 0.0501 | 0.0063 | -0.2492 | 1.0000 | | | | | | |
| CropLive | -0.0287 | 0.0283 | -0.0580 | -0.0656 | 0.0284 | -0.0609 | -0.1305 | 0.0619 | 1.0000 | | | | | |
| CornSoy | 0.0986 | -0.1371 | 0.0706 | -0.0047 | -0.1116 | -0.0320 | 0.0884 | -0.1797 | -0.0511 | 1.0000 | | | | |
| SmallGrain | 0.0478 | -0.0747 | 0.0714 | 0.0696 | 0.0036 | -0.0674 | 0.0716 | 0.0422 | 0.2492 | -0.0673 | 1.0000 | | | |
| Co-op | 0.0643 | 0.0224 | -0.0546 | 0.0161 | 0.0941 | -0.0559 | -0.0326 | 0.0795 | 0.0775 | -0.0962 | 0.0576 | 1.0000 | | |
| Farmers | -0.0236 | -0.0238 | -0.0167 | 0.0603 | 0.0301 | 0.0104 | 0.0006 | 0.0292 | 0.1088 | -0.0564 | 0.0957 | 0.3938 | 1.0000 | |
| Extension | 0.0207 | 0.0005 | 0.0336 | 01404 | -0.0386 | 0.0860 | 0.0538 | 0.0357 | 0.0453 | -0.0406 | 0.0624 | 0.1952 | 0.2710 | 1.0000 |

## APPENDIX F: RESULTS FOR MULTINOMIAL LOGIT REGRESSION WITH "NEVER A COVER CROP USER" AS BASE CASE AND TEST RESULTS

### Table F1: Results for multinomial logit regression with base case = 1[*]

| covercropuser | Coef. | Std. Err. | z | P>|z| | [95% Conf. Internal] | |
|---|---|---|---|---|---|---|
| **2[**]** q2years | 0.0273 | 0.0121945 | 2.24 | 0.025 | 0.0033992 | 0.0512007 |
| q3bhrsweek | 0.0077557 | 0.0078074 | 0.99 | 0.321 | -0.0075465 | 0.0230578 |
| Illinois | 0.1939175 | 0.4513201 | 0.43 | 0.667 | -0.6906537 | 1.078489 |
| Indiana | 1.293661 | 0.3742901 | 3.46 | 0.001 | 0.5600663 | 2.027256 |
| Minnesota | 0.227809 | 0.4409481 | 0.52 | 0.605 | -0.6364333 | 1.092051 |
| College | 0.6696128 | 0.3045912 | 2.20 | 0.028 | 0.0726251 | 1.266601 |
| Lths | -1.191036 | 1.03816 | -1.15 | 0.251 | -3.225793 | 0.8437207 |
| Q8aacresfarmed | 0.0000442 | 0.0001588 | 0.28 | 0.781 | -0.000267 | 0.0003555 |
| Propoflandowned | 0.1431526 | 0.1553453 | 0.92 | 0.357 | -0.1631186 | 0.4476237 |
| _cons | -4.419931 | 0.6114364 | -7.23 | 0.000 | -5.618324 | -3.221538 |
| **3[***]** q2years | 0.006372 | 0.0087071 | 0.73 | 0.464 | -0.0106935 | 0.234376 |
| q3bhrsweek | 0.0017019 | 0.0060322 | 0.28 | 0.778 | -0.0101211 | 0.0135248 |
| Illinois | 0.9870034 | 0.2918798 | 3.38 | 0.001 | 0.4149295 | 1.559077 |
| Indiana | 1.03038 | 0.2974941 | 3.46 | 0.001 | 0.4473018 | 1.613457 |
| Minnesota | 0.4032385 | 0.3183152 | 1.27 | 0.205 | -0.2206479 | 1.027125 |
| College | 0.2188042 | 0.2319522 | 0.94 | 0.346 | -0.2358138 | 0.6734221 |
| Lths | 0.4386745 | 0.4030484 | 1.09 | 0.276 | -0.3512858 | 1.228635 |
| Q8aacresfarmed | 0.0002152 | 0.0000939 | 2.29 | 0.022 | 0.0000312 | 0.0003992 |
| Propoflandowned | 0.0580428 | 0.1408264 | 0.34 | 0.733 | -0.2279719 | 0.3240575 |
| _cons | -3.062644 | 0.4217402 | -7.26 | 0.000 | -3.889239 | -2.236048 |

(covercropuser == 1 is the base outcome), 1[*] represents never a cover crop user, 2[**] represents cover crop user in past, 3[***] represents recent cover crop user
Number of obs = 1010, LR chi$^2$(18) = 57.66, Prob > chi$^2$ = 0.0000, Pseudo R$^2$ = 0.0483, Log Likelihood = -567.48419

### Table F2: Hausman Test

| Variables | Coefficients | | (b-B) | sqrt (diag(V_b – |
|---|---|---|---|---|
| | (b) partcov1 | (B) allcov | Difference | V_B))   S.E. |
| YearsFarmed | 0.0090655 | 0.006372 | 0.0026934 | 0.0021114 |
| Hrsweek | 0.0019927 | 0.0017019 | 0.0002909 | 0.0012397 |
| Illinois | 1.124809 | 0.9870034 | 0.1378055 | 0.717509 |
| Indiana | 1.187449 | 1.03038 | 0.1570692 | 0.0667009 |
| Minnesota | 0.451204 | 0.4032385 | 0.0548819 | 0.0588605 |
| College | 0.2831998 | 0.2188042 | 0.0643957 | 0.0394742 |
| Lths | 0.2727189 | 0.4386745 | -0.1659555 | 0.1190757 |
| AcresFarmed | 0.0003126 | 0.0002152 | 0.0000975 | 0.0000252 |
| PropOfLandOwned | -0.0034491 | 0.0480428 | -0.0514919 | 0.0855074 |
| _cons | -2.690537 | -3.062644 | 0.372107 | . |

   Difference in coefficients not systematic
Chi$^2$ (10)  =  (b – B) ' [(V_b-V_B) ^ (-1)] (b-B)
            =  -3.18  chi$^2$ < 0 ==> model fitted on these data fails to meet the asymptotic
                 assumptions of the Hausman test; see <u>suest</u> for a generalized test

**Table F3: Hausman Test**

| Varibles | Coefficients | | (b-B) | sqrt (diag(V_b – |
|---|---|---|---|---|
| | (b) partcov1 | (B) allcov | Difference | V_B))  S.E. |
| YearsFarmed | 0.02932252 | 0.0273 | 0.0020252 | 0.0032541 |
| Hrsweek | 0.0070242 | 0.0077557 | -0.0007315 | 0.0008638 |
| Illinois | 0.2090941 | 0.1939175 | 0.151767 | 0.0248481 |
| Indiana | 1.296461 | 1.293661 | 0.0028001 | 0.033411 |
| Minnesota | 0.2476202 | 0.227809 | 0.0198111 | . |
| College | 0.7006311 | 0.6696128 | 0.0310183 | 0.058423 |
| Lths | -1.183036 | -1.191036 | 0.0080006 | 0.0456545 |
| Q8aacresfarmed | 0.0000143 | 0.0000442 | -0.00003 | 0.0000252 |
| Propoflandowned | 0.1254239 | 0.1431526 | -0.0177286 | . |
| _ cons | -4.464096 | -4.419931 | -0.0441648 | 0.1481251 |

Difference in coefficients not systematic

$Chi^2 (9) = (b - B) ' [(V\_b\text{-}V\_B) \wedge (\text{-}1)] (b\text{-}B)$

$= -0.80$  $chi^2 < 0 ==>$ model fitted on these data fails to meet the asymptotic
assumptions of the Hausman test; see <u>suest</u> for a generalized test

**Table F4: Suest Test with Base = 1 (never a cover crop user)**

| | Coef. | Robust Std. Err. | z | P>|z| | [95% Conf. Internal] | |
|---|---|---|---|---|---|---|
| **partcov2_2** | | | | | | |
| q2years | 0.0293252 | 0.0121945 | 2.30 | 0.022 | .0042818 | .0543686 |
| q3bhrsweek | 0.0070242 | .0076554 | 0.92 | 0.359 | -.0079801 | .0220284 |
| Illinois | 0.2090941 | .4593153 | 0.46 | 0.649 | -.6911474 | 1.109336 |
| Indiana | 1.296461 | .3726103 | 3.48 | 0.001 | .5661587 | 2.026764 |
| Minnesota | .2476202 | .4439288 | 0.56 | 0.577 | -.6224642 | 1.117705 |
| College | .7006311 | .29295 | 2.39 | 0.017 | .1264598 | 1.274802 |
| Lths | - 1.183036 | 1.121205 | - 1.06 | 0.291 | - 3.380558 | 1.014487 |
| Q8aacresfarmed | .0000143 | .0001387 | 0.10 | 0.918 | -.0002575 | .0002861 |
| Propoflandowned | .1254239 | .0891731 | 1.41 | 0.160 | -.0493522 | .3002001 |
| cons | - 4.464096 | .5962144 | - 7.49 | 0.000 | - 5.632654 | - 3.295537 |
| **Partcov3_3** | | | | | | |
| q2years | .0057612 | .0095835 | 0.60 | 0.548 | -.0130222 | .0245445 |
| q3bhrsweek | .0015324 | .0061583 | 0.25 | 0.803 | -.0105377 | .0136026 |
| Illinois | .9872638 | .2925486 | 3.37 | 0.001 | .4138792 | 1.560649 |
| Indiana | 1.039737 | .3012768 | 3.45 | 0.001 | .4492455 | 1.630229 |
| Minnesota | .399655 | .313807 | 1.27 | 0.203 | -.2153955 | 1.014705 |
| College | .2236764 | .2392786 | 0.93 | 0.350 | -.2453011 | .6926539 |
| Lths | .4507997 | .3902645 | 1.16 | 0.248 | -.3141047 | 1.215704 |
| Q8aacresfarmed | .0002154 | .0000941 | 2.29 | 0.022 | .0000309 | .0003999 |
| Propoflandowned | .0404452 | .0921789 | 0.44 | 0.661 | -.1402222 | .2211125 |
| cons | - 3.040065 | .4682315 | - 6.49 | 0.000 | - 3.957782 | - 2.122348 |

$Chi^2 (9) = 13.61$

$Prob > Chi^2 = 0.1371$

# APPENDIX G: RESULTS FOR MULTINOMIAL LOGIT REGRESSION WITH "COVER CROP USER IN THE PAST" AS BASE CASE AND TEST RESULTS

## Table G1: Results for multinomial logit regression with base case = 2[**]

| covercropuser | Coef. | Std. Err. | z | P>\|z\| | [95% Conf. Internal] | |
|---|---|---|---|---|---|---|
| [1*] q2years | -.0273 | .0121945 | - 2.24 | 0.025 | -.0512007 | -.0033992 |
| q3bhrsweek | -.0077557 | .0078074 | - 0.99 | 0.321 | -.0230578 | .0075465 |
| Illinois | -.1939175 | .4513201 | - 0.43 | 0.667 | - 1.078489 | .6906537 |
| Indiana | 1.293661 | .3742901 | - 3.46 | 0.001 | - 2.027256 | -.5600663 |
| Minnesota | -.227809 | .4409481 | - 0.52 | 0.605 | - 1.092051 | .6364333 |
| College | -.6696128 | .3045912 | - 2.20 | 0.028 | - 1.266601 | -.0726251 |
| Lths | 1.191036 | 1.03816 | 1.15 | 0.251 | -.8437207 | 3.225793 |
| Q8aacresfarmed | -.0000442 | .0001588 | - 0.28 | 0.781 | -.0003555 | .000267 |
| Propoflandowned | -.1431526 | .1553453 | - 0.92 | 0.357 | -.4476237 | .1613186 |
| _cons | 4.419931 | .6114364 | 7.23 | 0.000 | 3.221538 | 5.618324 |
| [3***] q2years | -.020928 | .0141892 | - 1.47 | 0.140 | -.0487384 | .0068824 |
| q3bhrsweek | -.0060538 | .0093141 | - 0.65 | 0.516 | -.0243092 | .0122016 |
| Illinois | .793086 | .5196759 | 1.53 | 0.127 | -.2254602 | 1.811632 |
| Indiana | -.2632818 | .4567455 | - 0.58 | 0.564 | -1.158487 | .631923 |
| Minnesota | .1754295 | .527076 | 0.33 | 0.739 | -.8576206 | 1.20848 |
| College | -.4508087 | .3595668 | - 1.25 | 0.210 | - 1.155547 | .2539292 |
| Lths | 1.629711 | 1.087906 | 1.50 | 0.134 | -.5025453 | 3.761967 |
| Q8aacresfarmed | .0001709 | .0001718 | 0.99 | 0.320 | -.0001659 | .0005077 |
| Propoflandowned | -.0951098 | .1883121 | - 0.51 | 0.614 | -.4641948 | .2739752 |
| _cons | 1.357287 | .7100427 | 1.91 | 0.056 | -.0343711 | 2.748945 |

(covercropuser = = 2 is the base outcome), * 1 represents never a cover crop user, ** 2 represents cover crop user in past, *** 3 represents recent cover crop user

Number of obs = 1010, LR chi$^2$ (18) = 57.66, Prob > chi$^2$ = 0.0000, Pseudo R$^2$ = 0.0483, Log Likelihood = -567.48419

## Table G2: Hausman Test

| | Coefficients | | (b-B) | sqrt (diag(V_b – |
|---|---|---|---|---|
| | (b) partcov3 | (B) allcov | Difference | V_B)) S.E. |
| q2years | -.0137051 | -.020928 | .0072229 | .0035706 |
| q3bhrsweek | -.0046193 | -.0060538 | .0014345 | .0028569 |
| Illinois | .7208793 | .793086 | -.0722066 | .1182543 |
| Indiana | -.3337275 | -.2632818 | -.0704456 | .0999246 |
| Minnesota | .1633187 | .1754295 | -.0121107 | .1134647 |
| College | -.4286779 | -.4508087 | .0221308 | .0914492 |
| Lths | 1.37952 | 1.629711 | -.2501905 | .2118406 |
| Q8aacresfarmed | .000147 | .0001709 | -.0000239 | .000078 |
| Propoflandowned | -.4146509 | -.0951098 | -.3195412 | .4185341 |
| _cons | 1.373122 | 1.357287 | .0158346 | .1240262 |

Difference in coefficients not systematic

Chi$^2$ (9) = (b – B) ' [(V_b-V_B) ^ (-1)] (b-B)

= -0.98 chi$^2$ < 0 = = > model fitted on these data fails to meet the asymptotic assumptions of the Hausman test; see <u>suest</u> for a generalized test

## Table G3: Hausman Test

| | Coefficients | | (b-B) | sqrt (diag(V_b – |
|---|---|---|---|---|
| | (b) partcov2 | (B) allcov | Difference | V_B)) S.E. |
| YearsFarming | -.0293252 | -.0273 | -.0020252 | .0032541 |
| Hrsweek | -.0070242 | -.0077557 | .0007315 | .0008638 |
| Illinois | -.2090941 | -.1939175 | -.0151767 | .0248481 |
| Indiana | -1.296461 | - 1.293661 | -.0028001 | .033411 |
| Minnesota | -.2476202 | -.227809 | -.0198111 | . |
| College | -.7006311 | -.6696128 | -.0310183 | .058423 |
| Lths | 1.183036 | 1.191036 | -.0080006 | .0456545 |
| Q8aacresfarmed | -.0000143 | -.0000442 | .00003 | .0000252 |
| Propoflandowned | -.1254239 | -.1431526 | .0177286 | . |
| _cons | 4.464096 | 4.419931 | .0441648 | .1481251 |

Difference in coefficients not systematic

$Chi^2 (9) = (b - B) ' [(V\_b-V\_B) \wedge (-1)] (b-B)$

$= -0.80$  $chi^2 < 0 ==>$ model fitted on these data fails to meet the asymptotic assumptions of the Hausman test; see <u>suest</u> for a generalized test

## Table G4: Suest Test with Base = 2 (cover crop user in the past)

| | Coef. | Robust Std. Err. | z | P>\|z\| | [95% Conf. Internal] | |
|---|---|---|---|---|---|---|
| **Partcov1_1** | | | | | | |
| q2years | -.0293252 | .0127775 | - 2.30 | 0.022 | -.0543686 | -.0042818 |
| q3bhrsweek | -.0070242 | .0076554 | - 0.92 | 0.359 | -.0220284 | .0079801 |
| Illinois | -.2090941 | .4593153 | - 0.46 | 0.649 | - 1.109336 | .6911474 |
| Indiana | - 1.296461 | .3726103 | - 3.48 | 0.001 | - 2.026764 | -.5661587 |
| Minnesota | -.2476202 | .4439288 | - 0.56 | 0.577 | - 1.117705 | .6224642 |
| College | -.7006311 | .29295 | - 2.39 | 0.017 | - 1.274802 | -.1264598 |
| Lths | 1.183036 | 1.121205 | 1.06 | 0.291 | - 1.014487 | 3.380558 |
| Q8aacresfarmed | -.0000143 | .0001387 | - 0.10 | 0.918 | -.0002861 | .0002575 |
| Propoflandowned | -.1254239 | .0891731 | - 1.41 | 0.160 | -.3002001 | .0493522 |
| _cons | 4.464096 | .5962144 | 7.49 | 0.000 | 3.295537 | 5.632654 |
| **Partcov3_3** | | | | | | |
| q2years | -.0137051 | .0157504 | - 0.87 | 0.384 | -.0445754 | .0171652 |
| q3bhrsweek | -.0046193 | .0095445 | - 0.48 | 0.628 | -.0233262 | .0140876 |
| Illinois | .7208793 | .5388168 | 1.34 | 0.181 | -.3351822 | 1.776941 |
| Indiana | -.3337275 | .4594666 | - 0.73 | 0.468 | - 1.234266 | .5668106 |
| Minnesota | .1633187 | .5269085 | 0.31 | 0.757 | -.869403 | 1.19604 |
| College | -.4286779 | .3673131 | - 1.17 | 0.243 | - 1.148598 | .2912426 |
| Lths | 1.37952 | 1.271654 | 1.08 | 0.278 | - 1.112876 | 3.871917 |
| Q8aacresfarmed | .000147 | .0001676 | 0.88 | 0.380 | -.0001816 | .0004756 |
| Propoflandowned | -.4146509 | .5031208 | - 0.82 | 0.410 | - 1.40075 | .5714477 |
| _cons | 1.373122 | .7065389 | 1.94 | 0.052 | -.0116692 | 2.757913 |

$Chi^2 (9) = 22.80$

$Prob > Chi^2 = 0.0067$

**VITA**

Sukirti Nepal was born in a very beautiful Himalayan country, Nepal. She got her School Leaving Certificate in 1998 from Siddhartha Sishu Sadan, Hetauda, Nepal. After completing an intermediate degree in science in 2000 from Siddhartha Vanasthali Institute, Kathmandu, she joined Kantipur Engineering College, Tribhuvan University, Dhapakhel, Lalitpur to get her bachelor's degree in computer engineering.

She started her master's program in the Department of Agricultural Economics and Agribusiness at Louisiana State University in the fall of 2006. Upon completion of her master's degree, Sukirti hopes to work as an economist.