TILLAGE PRACTICES IN OKLAHOMA: PRODUCERS AND FARMS SPATIAL/REGIONAL CHARACTERISTICS

By

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CHAPTER I

INTRODUCTION

Tillage is defined as any cultivation method that is performed prior to planting for seedbed preparation and after planting for weed control. The most important functions of tillage are to prepare the seedbed, to control weeds, to control insects, to control plant diseases, and to manage crop residue (Gebhardt et al. 1985). For centuries, tillage was the only means available to perform these functions. It was therefore necessary and essential for crop production to prepare lands using traditional tillage farming techniques.

In the early ages, tillage was performed by the means of human labor using wooden sticks, stone, and then metal for land preparation. The plow was invented and animals replaced human labor. The most severe tillage system is intensive tillage. Intensive tillage is a cultivation method that uses machines (e.g. moldboard plow; chisel plow; offset disk) to prepare a suitable seedbed, reduce competition from other plants, improve surface drainage, and change the structure of soil. The Conservation Technology Information Center (CTIC) defines intensive tillage as a tillage system that includes several tillage passes and leaves less than 15 percent of crop residue after planting. The reduction in surface residue leaves the soil surface exposed without vegetative protection. A major drawback of intensive tillage is that it exposes soil to erosion. If erosion occurs long term productivity of the land can be reduced.

The development of chemical herbicides enabled producers to substitute herbicides for tillage to manage weeds. Originally chemical herbicides were substituted for post planting weed control. As more effective herbicides became available, and as the cost of post planting weed control with herbicides became relatively less expensive than the cost of post planting cultivations, the use of herbicides became standard practice for row crop producers, especially for major summer crops such as corn and soybeans. Since winter annuals such as wheat, rye, oats, and barley did not require in season cultivation, post planting herbicide use was not as common for them.

The least intensive tillage system is conservation tillage. The CTIC defines conservation tillage as a minimum disturbance cultivation method that includes the use no-till/strip-till, ridge-till, and mulch-till that leaves more than 30 percent of the previous crops' residue on the soil surface. No-till or zero-tillage is the most conserving of crop residue and consists of leaving the soil undisturbed from harvest to planting except for placing seeds into soil. Strip tillage is a form of conservation tillage that combines the techniques of no-till but includes tillage of a narrow strip for placement of seeds. It removes residue from a narrow strip where the seed is planted. This method allows a warmer seedbed which favors germination in some soils especially in poorly wet drained soils (Al-Kaisi and Licht 2004). Ridge-till also called till-planting is a system in which seeds are planted into a seedbed on a hill. This method results in furrows between rows that may be used to facilitate furrow irrigation and also prepares a warmer dryer seedbed. Such tillage practice may remove weeds, may influence crop/weed interactions, but also may promote plant germination (Forcella and Lindstrom 1988).

Stubble mulch tillage, also called mulch tillage is a cultivation method that leaves at least 30% of the soil surface covered by crop residue before planting. The main purpose of this technique is to retain crop residues on the soil surface for protection against wind and water erosion, promote seed germination, improve infiltration, and prevent from soil crusting (Fenster, Woodruff, Chepil, and Siddoway 1965).

In addition to the CTIC definition of conservation tillage (comprised of no-till/strip-till, ridge-till, and mulch-till), in the survey vertical tillage was also considered as a conservation tillage technique that leaves at least 30 percent of crop residue on soil after planting. Vertical tillage is a tillage system designed to fracture soil but not move it horizontally. Vertical tillage tools include vertical (rather than concave) disks and straight narrow shanks rather than shanks designed to move soil from side to side. Vertical tillage has been promoted as a method to remediate and/or prevent soil compaction. In some cases vertical tillage tools may be set to till deeper than intensive tillage tools such as moldboard and chisel plows to break a plow pan or clay pan layer. Soil compaction affects the soils ability to absorb moisture. The plant roots growth is limited which can affect yields. Vertical tillage is promoted as a method to improve air circulation and water infiltration by breaking-up compaction with minimal soil disturbance. Since, on average vertical tillage is expected to leave at least 30 percent of the previous crops' residue on the soil surface after planting, it is assumed to be a conservation tillage method. However, tillage machinery ownership and operating costs would not necessarily be reduced by shifting from intensive to vertical tillage.

By CTIC definition these tillage (no-till/strip-till, ridge-till, and mulch-till) methods leave at least 30 percent of the previous crops' residue on the soil surface.

Collectively, they are called conservation tillage. However, the quantity of surface residue, the number of tillage passes, the investment in tillage machines, and the cost of tillage, can vary greatly between a no-till system and a mulch-tillage system even though they are both classified as conservation tillage.

Managing weeds in a conservation tillage system, especially no-till, is more difficult than under intensive tillage. In addition to herbicides to control weeds post planting, conservation tillage requires a means to kill vegetation prior to planting. Farmers refer to chemicals used to kill preplant vegetation as “burn down” herbicides. The most common “burn down” herbicide in the early days of conservation tillage was paraquat which was introduced in 1961. For no-till corn production, paraquat was used to kill surface vegetation prior to planting and selective herbicides were applied to manage post planting weeds. Paraquat is a very effective “burn down” herbicide; however, it is toxic to mammals. In the mid 1970s glyphosate was introduced as an alternative herbicide to the more toxic paraquat. Over time glyphosate became the burn down herbicide of choice.

In addition to herbicides for weed management, no-till requires a seeder (planter or drill) that can place seeds for germination effectively into untilled soil. The improvement in no-till planters which permitted direct seeding in a variety of residues and soil conditions increased the likelihood of successful conservation tillage cropping systems. However, the cost of no-till seeders is substantially greater than the cost of intensive tillage seeders (Epplin et al 2005).

Prior to settlement, lands in western Oklahoma were covered with native prairie grasses that held the soil in place. The first settlers used traditional intensive tillage methods to prepare seedbeds and control weeds. Intensive tillage exposed the soil, and under conditions of limited rainfall, hot dry winds resulted in wind erosion. In 1933, Oklahoma farmers planted more than 15.7 million acres to annual crops (including 4.4 million acres of wheat, 4.1 million acres of cotton, 3.3 million acres of corn, and 1.1 million acres of oats) (USDA-NASS 2008). One of the major ecological consequences of the intensive tillage of shallow soils in Oklahoma was the dust bowl of the 1930s. By 2000, acres planted to annual crops in the state, plus acres in the Conservation Reserve Program (CRP), decreased to 9.1 million (USDA-NASS 2008). More than 40 percent of land cropped in 1933 has been converted to other uses, mostly improved pasture used for beef production. It can be assumed that the vast majority of the 6.6 million acres that were cropped in 1933 that are no longer planted to annual crops are seldom tilled. Most (75 percent) of the Oklahoma cropland not in pasture and not in the Conservation Reserve Program (CRP) is seeded to continuous winter wheat (USDA-NASS 2008).

Problem statement

Based on data reported by the CTIC, the use of no-till (NT) for crop production in Oklahoma is low compared to the national average. In 2004, NT was used on less than six percent of the acres cropped in the Southern Plains of Texas and Oklahoma (acres no-tilled 5.4 %; acres ridge tilled 0.3%; acres mulch tilled 23.7%; total acres CST 29.5%; (CTIC 2004)). This is less than one-quarter of the national average of 22.6 % (CTIC 2004) (acres no-tilled 22.6 %; acres ridge tilled 0.8%; acres mulch tilled 17.3%; total acres CST 40.7%; (CTIC 2004)). However, as noted, 6.6 million Oklahoma acres that were cropped in 1933 are no longer planted to annual crops. These acres are seldom tilled but are not included in the aggregate CTIC statistics. The CTIC data do not account for transitions from cropland to pasture or transitions from pasture to cropland.

NT production systems were originally developed for row crops, primarily corn. For corn producers, that had learned how to substitute herbicides for in season cultivation, adoption of a burn down herbicide and a no till corn planter did not require a major investment. The original NT corn planters were not drastically different from conventional corn planters. The use of NT for corn production increased as corn producers learned the conditions for which NT was more economical than intensive tillage (IT). However, the hot dry summers in western Oklahoma are not conducive to dryland corn production. For most of the region continuous monoculture wheat has a comparative advantage. Most studies of conservation tillage (CST) versus IT for continuous wheat production in the region have found that CST is not consistently more economical than IT.

Several studies of continuous wheat production in the region have found that when wheat is grown year after year in the same field, grain yield is reduced when a substantial quantity of wheat residue from the previous wheat crop is retained on the surface (Daniel et al 1956; Zingg and Whitfield 1957; Harper 1960; Davidson and Santelmann 1973; Heer and Krenzer 1989; Epplin, Al-Sakkaf, and Peeper 1994; Epplin and Al-Sakkaf 1995; Decker et al. 2009). Results of some of these studies are summarized in Table 1. In every case the yield of the IT treatment was found to be greater than the yield of the alternative treatment. On average the yield loss associated with the NT or mulch tillage treatment was about 15 percent.

The finding that CST yields are lower than IT yields when winter wheat is grown continuously is consistent with findings from other crops in other regions. For example

Vyn (2004) reported results of an 18-year study of continuous corn in Indiana. He reported an average IT yield of 167 bushels per acre and an average NT yield of 146 bushels per acre (Vyn 2004). Similarly Al-Kaisi et al. (2002) reported results of a 15-year study of continuous corn in Iowa. They found average yields of 135 bushels per acre for continuous IT corn and 123 bushels per acre for continuous NT corn

Based on the research results reported from Oklahoma continuous wheat tillage trials, and from Iowa and Indiana for continuous corn tillage trials, when the same crop is grown continuously expected grain yields are lower in CST plots.

A second finding of the results reported by Vyn (2004) and Al-Kaisi et al. (2002) is that corn grain yields are approximately 10 percent greater when grown in a corn-soybeans rotation relative to corn yields when corn is grown continuously. When corn was grown in a crop rotation with soybeans the yield difference between NT and IT was minimal. Data are not available from long term trials of wheat in rotation with other crops in Oklahoma. However, based on the results from the long term corn-soybean rotations in other regions, it could be hypothesized that if a crop could be identified that would fit in a rotation with wheat, the yield penalty from use of NT rather than IT might be reduced or eliminated. The predominance of continuous cropping to wheat, and the yield penalty associated with the use of NT with continuous cropping, may explain the low rate of NT use as reported by the CTIC for Oklahoma.

Table I-1. Summary of wheat grain yield results from prior Oklahoma research trials of alternative tillage systems for continuous monoculture winter wheat

			Wheat yield in bushels per acre	
Authors	**Location**	**Years**	**Intensive tillage**	**No-till or other**
Daniel et al. 1956	Alfalfa	1942-1951	18.8	14.8
Zingg and Whitfield 1957	Cherokee	1942-1951	19.4	14.4
Zingg and Whitfield 1957	Stillwater	1941-1952	27.2	22.2
Harper 1960	Perkins	1941-1957	19.8	Basin lister: 17.9
				One-way disk: 18.3
				Sweeps: 19.0
Davidson and Santelmann 1973	Cherokee	1966-1969	26.6	Mulch: 18.8
Heer and Krenzer 1989	Stillwater	1982-1985	45.7	41.5
Heer and Krenzer 1989	Lahoma	1982-1985	40.9	40.0
Epplin et al. 1994	Lahoma	1977-1986	34.2	24.3
Decker et al. 2009				
Grain only	Alfalfa, Garfield, and Kingfisher Counties	2002-2004	40.5	35.5
Dual purpose		2002-2004	43.2	36.9

Additional studies have found that the economics of NT for continuous wheat production in the region depends on farm size (Epplin and Tice 1986; Epplin et al. 2005; Decker et al. 2009). In part because of the investment required in NT drills and seeders, IT is relatively more economical for small sized continuous wheat farms. For two different farm sizes (640 acres and 2,560 acres), Decker et al. (2009) found that NT is relatively more economical for the larger farm size. For the smaller farm, the IT system was found to produce more net returns than the NT system (Decker et al 2009).Although the wheat grain yields are lower under NT than under IT, for larger farms, savings from NT production costs were large enough to offset the loss in wheat grain yields.

Motivation

The choice of tillage system is one of the most important decisions a farmer has to make. Producers have characteristics and preferences that are different from one to another. These differences in producers' characteristics are important to understand; knowing how producers' characteristics affect the choice of tillage system could be useful information for policy makers in developing adequate policies and recommendations.

Theoretically, producers choose a production system that maximizes their expected profit. Farmers currently using IT practices can be expected to have a substantial investment in machinery and equipment. On many farms in Oklahoma the effective life of tillage machines and tractors used for powering these machines may exceed ten years. NT wheat production requires the use of either a NT grain drill or a NT air seeder. These machines require a substantial investment. Based on the CTIC data, some Oklahoma producers have made these investments and others have not. Definitions of tillage systems used by the CTIC will be used throughout this thesis. The definitions are as follows: “Intensive-till or conventional-till involve full-width tillage and may involve one, three or perhaps up to 15 tillage passes. There is less than 15 percent residue on the soil surface after planting. Moldboard plowing and/or multiple tillage trips are involved”; “Reduced-till systems are somewhat similar to mulch till in that they involve full-width tillage, use the same implements and may use one to three tillage trips. Reduced-till, however, leaves 15-30 percent residue on the soil surface after planting” (a system that uses fewer mechanical soil tillage than IT and herbicides for weed control. The CTIC defines RT as one to three tillage passes and leaves 15 percent to 30 percent of residue of the previous year's crop on the soil surface after planting); “Conservation tillage is any cropland system that leaves at least one-third of the soil covered with crop residue after planting. Conservation tillage types include no-till/strip-till, ridge-till and mulch-till” (CTIC Crop Residue Management Survey 2006, p 9).

The objective of the research reported in this thesis is to determine characteristics of Oklahoma producers that use each of the three systems, intensive tillage (IT), reduced tillage (RT), and conservation tillage (CST). Additional objectives are to determine the proportion of Oklahoma farmers that use IT, the proportion that use RT, and the proportion that use CST. Secondary objectives consist of determining the proportion of acres intensively tilled (acres under IT), the proportion of acres reduced tilled (acres under RT), and the proportion of acres tilled using CST techniques (acres under CST).The tertiary objectives are to determine characteristics of farms and farmers that fall into each of the three (IT, CST, RT) categories in the State of Oklahoma and by its regions.

Additional objectives include determining the relationship between producers and farms characteristics and the use of tillage: how personal/behavioral characteristics affect the choice of tillage practices; how physical characteristics affect the choice of tillage practices; how financial/economic characteristics affect the choice of tillage practices; and how producers' perception on CST affects the use tillage practices.

Overview

This thesis includes five additional chapters which contain: a presentation of results for each question included in the survey; a comparative analysis of farmers and farms characteristics for producers that use intensive tillage exclusively (IT) and conservation tillage exclusively (CST); a multinomial logistic approach to determine how these characteristics affect the use of a tillage practice; a combination of tabulation method and logistic procedure to identify farms and farmers spatial characteristics for the seven agricultural districts in Oklahoma. This first chapter includes a literature review of prior studies, a discussion of the methods used to conduct the survey and a discussion of the methods used to achieve the objectives of this study.

Many studies have been conducted to determine relationships between the use of tillage practices and the characteristics of the farm and the farmer. Several studies found that the total crop acres farmed and farming experience are positive and significant factors in explaining the use of CST; some have found that education level is negatively related to the use of CST and that the perception or the recognition of erosion by the producer is also a determinant factor in CST use (Ervin and Ervin 1982; Rahm and Huffman 1984; Belknap and Saupe 1988; Gould, Saupe and Klemme, 1989).

Belknap and Saupe (1988) identified factors affecting the use of no-plow tillage in Wisconsin, focusing on the farm family resources. They used a PROBIT model to identify variables that are associated with the probability a farmer uses no-plow tillage considering farmers goals, attitudes and program participation. Based on their findings, farmers' education level and the number of years of farming are not associated with the likelihood of use; but users of the no-plow system have larger farm size (Belknap and Saupe 1988). Similar results were found by Rahm and Huffman (1984); Gould, Saupe, and Klemme (1989); and Ereinstein and Iniguez (1997).

Rahm and Huffman (1984) determine the role of human capital and other variables in the use of tillage systems in Iowa using a linear and PROBIT model. Their results show that the size of the farm is positively related to use of CST. Furthermore, the farmer's education level is negatively related to the use of CST and farming experience is positively related to the use of CST (Rahm and Huffman 1984).

The operator's age was found to be one of the most significant factors that affect the use of CST by Gould, Saupe, and Klemme (1989). Their results imply that younger farmers are more likely to adopt CST. They also found the acres planted for crop production to influence positively the use of CST while farmer's education level negatively affects the use of CST (Gould, Saupe, and Klemme 1989).

Contrary to Rahm and Huffman (1984) and Gould, Saupe, and Klemme (1989) some studies found that the farmer's education level is positively related to the use of CST (Ervin and Ervin 1982; Wu and Badcock 1997; Iqbal, Khan, and Ahmad 2002) but more farming experience is negatively related to use (Ervin and Ervin 1982; Wu and Badcock 1997).

Iqbal, Khan, and Ahmad (2002) considered different variables that are more likely to affect the decision of a farmer to adopt new recommended varieties. They included in their analysis variables such as farm size, education, age, and farming experience using a PROBIT model. They found that farm size and education level were determinant factors in the use of recommended varieties and that the coefficients on age and tenure of the farmer were not significantly different from zero (Iqbal, Khan, and Ahmad 2002).

Correspondingly, Wu and Badcock (1997) identified factors that are determinant in the farmer’s decision to adopt management practices such as soil testing and CST. Their results suggest that experience and education level have the most significant effects on the use of CST; farmers with more experience are less likely to use CST (Wu and Badcock 1997).

Similarly, Ervin and Ervin (1982) concluded that less experienced (or younger) farmers are more likely to use CST. Ervin and Ervin (1982) identified factors affecting the use of soil conservation practices considering farmer's perception of the degree of erosion problem on his/her land, farmer’s decision to use tillage practices, and their effort for soil conservation. According to their findings, less experienced farmers are more likely to use conservation practices. In other words, more technical information programs are required to educate more experienced farmers about the consequences of CST (Ervin and Ervin 1982).

Based on previous studies, education can either be positively or negatively related to the use of CST. Most studies have found that farm size is positively related to the use of CST. However, other studies have reported that farm size and/or education are not significant in determining and explaining the use of CST (Ervin and Ervin 1982; D'Emden, Llewellyn, and Burton 2007).

D'Emden, Llewellyn, and Burton (2007) studied the use of CST in Australia cropping regions using a duration analysis. Their results suggest that using time duration analysis, farm size and education level are insignificant factors that influence the probability of CST use which is in contradiction with some previous findings (Gould, Saupe, and Klemme 1981 ; Rahm and Huffman 1984; Belknap and Saupe 1988; Ereinstein and Iniguez 1997) . According to D'Emden, Llewellyn, and Burton (2007), their contradictory finding results from other explanatory variables used in the model that may have captured the explanatory power of farm size and education.

The consideration of livestock on farm was found to be significantly related to the adoption of CST. Erenstein and Cadena (1997) determined the factors affecting the use of CST practices in a hillside maize production system in Mexico. Some farmers adopted RT, some adopted the mulch component, and others adopted both. They found that the use of RT alone is related to farm size and that slope appeared to be the most relevant factor to explain the use of the mulch component alone. Farm size is the most important factor affecting the use of both components. The study shows that the use of CST is the result of the simultaneous use of both components of the technology, and also they found that livestock has a positive significant effect on the use as well as the availability of family labor (Erenstein, and Iniguez 1997).

Fernandez-Cornejo, Daberkow, and McBride (2001) determine the factors affecting the use of two agricultural technologies (agrobiotechnology or genetic engineering GE and precision agriculture PA) using a TOBIT model. For GE technologies the adoption is invariant to farm size which is the case of herbicide-tolerant soybeans; however for PA technology there is a positive relationship with farm size, which is the case of herbicide-tolerant Bt-corn. The level of the farmer's education was found to be a good indicator of the overall level of management (Fernandez-Cornejo, Daberkow and McBride 2001).

One important factor in the use of CST is whether or not the land is owned or rented. Lee and Stewart found lower use of CST among full owner operators and the reason maybe because they operate fewer acres than part-owners or tenants (Lee and Stewart 1983). In contrast with their finding, Barry and Baker (1977) found that full owners have a longer planning horizon and thus are more likely to use CST (Barry and Baker 1977).

Herrera and Sain (1999) identified the adoption of maize CST in Panama. They found that the adoption of CST was favored generally by the cost savings and especially it is promoted by the large farm where livestock is important (Herrera and Sain 1999).

In Oklahoma, studies on wheat prove the evidence of a difference in grain yields under different tillage systems. In a study conducted by Davidson and Santelmann in 1973, yields from the plow treatments were higher than those from CST and minimum treatments (Davidson and Santelmann 1973). A 10-years study in Oklahoma by Daniel et.al (1956) found that under stubble mulch system, wheat grain yields are lower than yields under IT methods (Daniel et al. 1956). Moreover, of all tillage systems in their study, wheat grain yields on plowed lands are the highest and wheat grain yields on NT lands are the lowest (Daniel et al. 1956). Similar results were found by Epplin et al.(1994) a 10-years study, of all treatments under NT treatment wheat grain yields were the lowest and the highest under plow treatments (Epplin et al. 1994). In addition, Decker et al. (2009) found that the average wheat grain yields under IT were greater than the average wheat grain yields under NT (Decker et al. 2009). However, the average wheat forage yields are lower under IT than under CST (Decker et al. 2009). Similar findings were reported in a 17-years study by Harper in 1960. He found that under IT the average wheat grain yields exceeded by 25 percent the average wheat grain yields of all other tillage practices (Harper 1960).

The Survey

This study is based on primary data collected from a survey conducted by the Oklahoma Agricultural Statistics Service (OASS). OASS designed the survey to determine tillage practices used in the state of Oklahoma and to determine if farmers' characteristics differ across tillage system. The OASS randomly selected farmers from their database of known Oklahoma crop producers; 9,500 surveys were mailed and of the returned surveys 1,703 were usable. The random sample was limited to producers with at least 80 acres of cultivated land to remove ranchers and small farmers. The survey was conducted in 2008 and included 27 questions.

Producers were asked background information regarding their age, education, experience with current tillage practices, and off farm employment. They were asked to report the number of hours worked off farm per week as well as the share of income earned from off-farm employment. They were also asked to list their: tillage practices; acres farmed; acres rented; crop rotation; wheat production practices; crop and livestock sales; split of farm income between crop and livestock sales; machines owned; perceived benefits of conservation tillage; perceived problems of conservation tillage; and perceived knowledge of conservation tillage.

The frequencies of responses for each of the 27 questions were computed using the SAS FREQ and SAS MEANS procedures. These findings are reported in Chapter II. Chapter III includes a summary of selected characteristics of farmers and farms by comparing exclusive categories. CST and IT are compared using results computed with the SAS FREQ, SAS MEANS, and SAS TTEST procedures. Chapter IV includes an analysis of the relationship between the different characteristics and the dependent variable which is the choice to use a tillage practice using procedures GLIMMIX and LOGISTIC. A multinomial logistic model is used to determine the probabilities and marginal probabilities of the different variables. Chapter V includes results obtained via SAS FREQ, GLIMMIX, and a LOGISTIC procedures used to determine producers and farms spatial characteristics relative to the choice to use a tillage practice. Lastly, a summary of the major findings of the survey as well as recommendations and general conclusions are included in Chapter VI.

CHAPTER II

SURVEY RESULTS

Producers were asked to rate their understanding of conservation tillage practices. The results are shown in table II-1. The mean rate for the understanding of conservation tillage practices reported by respondents is six on a scale from zero to ten (table II-1).

Table II-1. Perceived knowledge of conservation tillage practices (0-10; 0 = no knowledge; 10 = very knowledgeable)

Mean	Std Dev	Number
6[a]	2.5	1,645[b]

[a] On a scale from zero to ten, farmers rated their understanding of conservation tillage practices to be 6 on average.
[b] The total number of respondents was 1,645.

Eight percent of the respondents reported they have no knowledge of conservation tillage methods and an equal proportion of the respondents (eight percent) rated ten, being the highest, their perceived knowledge of conservation tillage practices. Twelve percent of the respondents rated their perceived knowledge of conservation tillage practices between one and three, 35 percent rated between four and six, the remaining 37 percent rated between seven and nine (table II-2).

Table II-2. Perceived knowledge of conservation tillage practices rates

	0-10; 0 = no knowledge; 10 = very knowledgeable				
	0	**1-3**	**4-6**	**7-9**	**10**
Number	129[a]	205	601	631	137
Percent	8%[b]	12%	35%	37%	8%

[a] On a scale from zero to ten, 129 farmers rated their understanding of conservation tillage practices to be zero.
[b] On a scale from zero to ten, eight percent of the respondents rated their understanding of conservation tillage practices to be zero.

Tillage definitions (intensive tillage (IT), reduce tillage (RT), and conservation till (CST)) used by the Conservation Technology Information Center (CTIC) were printed on the questionnaire. Intensive tillage "includes several tillage passes and leaves less than 15 percent of residue on the soil surface after planting"; reduced tillage includes "one to three full width tillage passes and leaves 15 to 30 percent of residue on the soil surface after planting"; and conservation till is "minimum soil disturbance; practices that fall under no-till including strip-till, ridge-till, and vertical-till".

According to the CTIC definitions, IT is a "full-width tillage that is performed prior to and/or during planting, that generally involves plowing with a moldboard plow and/or other intensive tillage equipment. Less than 15 percent residue cover remains on the soil surface after planting"; RT is a "full-width tillage usually involving one or more tillage passes over the field performed prior to and/or during planting, that leaves 15-30 percent residue cover after planting"; and CST is "any tillage and planting system that maintains at least 30 percent of the soil surface covered by residue after planting to reduce soil erosion. No-till, ridge-till and mulch-till are thee common types of conservation tillage systems" (Sandretto and Payne 2006, p102).

The survey form did not include the term “conservation tillage”. On the survey form, the category for the least soil disturbance is called “No-till”. It was defined as “minimum soil disturbance; practices that fall under no-till including strip-till, ridge-till, and vertical-till”. The classifications of tillage systems used on farms in the CTIC definitions are based on the percent of residue cover remaining on the soil surface after planting not on the type of tillage implement. If the residue cover is less than 15 percent, the CTIC defines the system as IT; RT residue cover is between 15-30 percent. For the system to be defined as CST, residue cover remaining on soil surface after planting must be greater than 30 percent. This is somewhat ambiguous when, because of a lack of residue cover remaining on the soil surface before planting, a crop planted with a no-till drill and no other tillage operations are performed might not meet the criteria of CST as defined by the CTIC. Alternatively, a producer that decides to burn crop residue could qualify for IT although he did not use a moldboard plow or other intensive tillage operations on his land. On the other hand, a chisel plow is listed as a potential implement for mulch tillage (CTIC 2006) which is classified as CST but a chisel plow could also be used as part of an IT system.

Producers reported acres cropped and crops grown under each system. Findings are included in table II-3: IT was used on 43 percent of the acres planted to annual crops, RT was used on 28 percent, and CST on 29 percent. The third row of table II-3 shows that many respondents use more than one system. A total of 1,703 producers were in the survey (eight missing values on farm size: 1,703–8=1,695). These 1,695 respondents checked a total of 2,388 tillage systems. The results in table II-3 show 1,113 unisystem producers versus 582 multisystem producers. Unisystem producers are defined as producers that reported they planted all their crop acres using only one of the three tillage categories; multisystem producers are those that plant acres using more than one tillage system as defined on the survey.

In term of proportions of producers, more than a third of producers (34 percent) are using more than one tillage practice on their farm. Based on the number of acres reported by the users of one tillage system (unisystem) and those that use several systems (multisystem) on their land, 54 percent of the survey acres were planted by producers of one tillage system and the rest of 46 percent were planted by farmers that used more than one tillage system. In addition, multisystem farmers reported on average more acres than unisystem farmers (about 65 percent greater) (table II-3).

Table II-3. Of the total acres in the survey, acres intensively tilled; tilled using conservation method; and reduced tilled; and number of respondents.

	Tillage system used on farm			
	Intensively tilled [a]	Reduced tilled [b]	Conservation tilled [c]	Total
Acres	632,319[d]	403,303	428,077	1,463,700
Percent	43%[d]	28%	29%	100%
Respondents	1,080[e]	733	575	1,695
Number of respondents that are using one tillage system or more than one tillage system				
Unisystem [f]	618	286	209	1,113
Multisystem [g]	462	447	366	582
Average acres reported by respondents of only one and more than one tillage system				
Unisystem	609	668	1,048	707
Multisystem	554	475	571	1,164
Proportion of acres : sum of all proportions across tillage groups is equal to 100%				
Unisystem	26%	13%	15%	54%
Multisystem	18%	14%	14%	46%
Proportion of acres: sum across each row for the three tillage groups is equal to 100%				
Unisystem	48%	24%	28%	100%
Multisystem	38%	31%	31%	100%
Proportion of acres: sum across each column for the three tillage groups is equal to 100%				
Unisystem	59%	47%	51%	54%
Multisystem	41%	53%	49%	46%

[a] This includes several tillage passes and leaves less than 15 percent of residue on the soil surface after planting.

[b] This includes one to three full width tillage passes and leaves 15-30 percent of residue on the soil surface after planting.

[c] Minimum soil disturbance that leaves more than 30 percent of the previous crop's residue on the soil surface after planting; practices assumed to fulfill this residue requirement include no-till, strip-till, ridge-till, mulch till, and vertical-till.

[d] The total number of acres intensively tilled by respondents in the survey is 632,319 which represent 43 percent of the total acres planted to annual crops reported by surveyed producers.

[e] Number of respondents that reported some intensively tilled acres.

[f] Producers that reported they planted all their crop acres using only one of the three tillage categories.

[g] Producers are those that plant acres using more than one tillage system as defined on the survey.

Table II-4 includes a listing of crops grown on farms that use IT, RT, and CST.

The average acres presented in table II-4 are calculated based on the total number of producers that reported they IT some of their crop acres (1,080 farms). Thus, the average of 522 acres for IT wheat does not necessarily reflect the average acres planted by only wheat growers that are in that category (IT). A total of 1,032 producers grow wheat using IT of the 1,080 producers that are in the category (IT). On average 547 acres (564,189/1,032) was IT by the 1,032 farmers that grow wheat using IT.

The average IT acres planted to annual crops per farm is 585 acres of which on average 89 percent of the acres were planted to wheat, two percent to corn, three percent to cotton, two percent to sorghum, one percent to soybeans, and three percent planted to other crops (Table II-4).

Table II-4. Acres farmed to annual crops by respondents that reported they intensively tilled some of their crop acres

Annual Crops	Mean	Std Dev	Total Acres	Percent	Number
Wheat	522[a]	1,314	564,189[b]	89%[b]	1,032[c]
Corn	11	286	11,841	2%	52
Cotton	16	2,002	17,388	3%	30
Sorghum	13	128	14,105	2%	106
Soybeans	5	288	5,856	1%	28
Other Crops	18	303	18,941	3%	113
Total	585[d]	1,362	632,319		1,080[e]

[a] Of the average number of acres intensively tilled (585 acres) , 522 were seeded to wheat.
[b] Of the total acres intensively tilled to annual crops in the survey, 564,189 (89 percent) were seeded to wheat.
[c] 1,032 farmers reported they intensively tilled some acres of wheat.
[d] The average acres intensively tilled to annual crops is 585. The average acres intensively tilled to annual crops might not necessarily reflect the overall average acres farmed; some farmers might alternatively plant some of their crops using conservation tillage practice or reduced tillage.
[e] A total of 1,080 respondents reported they intensively tilled some acres of annual crops.

As shown in table II-5, 575 producers planted some of their acres under CST. The means reported in table II-5 are calculated by dividing the total acres of the selected crop by the 575 farmers in the category. The average acres planted to annual crops using CST is 744 acres of which on average 67 percent of the acres were planted to wheat, nine percent seeded to corn, three percent to cotton, ten percent to sorghum, eight percent to soybeans, and the remaining four percent planted to other crops.

Table II-5. Acres farmed to annual crops by respondents that reported using conservation tillage on some of their acres

Annual Crops	Mean	Std Dev	Total Acres	Percent	Number
Wheat	498[a]	825	286,189[b]	67%[b]	496[c]
Corn	67	656	38,251	9%	88
Cotton	23	371	13,422	3%	34
Sorghum	71	350	41,109	10%	126
Soybeans	57	509	32,757	8%	70
Other Crops	28	445	16,349	4%	70
Total Acres	744[d]	1,111	428,077		575[e]

[a] Of the average number of acres tilled using conservation tillage , 498 were seeded to wheat. (Is this the number of CST acres or is this the number of wheat acres on farms on which CST was used on some acres?)

[b] Of the total acres tilled using conservation tillage to annual crops in the survey, 286,189 (67 percent) were seeded to wheat.

[c] 496 farmers reported they tilled using conservation tillage some acres of wheat.

[d] The average acres tilled using conservation tillage to annual crops is 744. The average acres tilled using conservation tillage to annual crops might not necessarily reflect the overall average acres farmed; some farmers might alternatively plant some of their crops using intensive tillage practice or reduced tillage .

[e] A total of 575 respondents reported they tilled using conservation tillage some acres of annual crops.

The average RT acres planted to annual crops reported in table II-6 per farm is 552 acres of which on average 85 percent were planted to wheat, three percent to corn, four percent to cotton, four percent to sorghum, one percent to soybeans, and three percent planted to other crops such as rye. There were 734 farmers in this category; therefore the means reported are calculated by dividing the total number of acres by the 734 producers (table II-6).

Table II-6. Acres farmed to annual crops by respondents that reported they reduced tilled some of their crop acres

Annual Crops	Mean	Std Dev	Total Acres	Percent	Number
Wheat	470[a]	697	344,553[b]	85%[b]	676[c]
Corn	14	368	9,943	3%	35
Cotton	21	1,359	15,125	4%	23
Sorghum	22	209	15,880	4%	95
Soybeans	8	220	5,587	1%	25
Other Crops	17	179	12,215	3%	63
Total Acres	552[d]	819	403,303		734[e]

[a] Of the average number of acres reduced tilled , 471 were seeded to wheat.
[b] Of the total acres reduced tilled to annual crops in the survey, 345,754 (85 percent) were seeded to wheat.
[c] 676 farmers reported they reduced tilled some acres of wheat.
[d] The average acres reduced tilled to annual crops is 552. The average acres reduced tilled to annual crops might not necessarily reflect the overall average acres farmed; some farmers might alternatively plant some of their crops using conservation tillage practice or intensive tillage.
[e] A total of 734 respondents reported they reduced tilled some acres of annual crops.

Producers were asked to report the number of tillage passes they typically do when using IT, RT, and CST. On average producers make 3.8 tillage passes on IT acres, 2.1 tillage passes on RT acres, and 0.5 tillage passes on CST acres (table II-7). As expected, producers under IT reported doing more tillage passes on their farms than RT producers which also reported more tillage passes than CST producers. Based on the results in table II-7, by summing the last column, 2,720 producers reported they tilled their lands using a tillage system or a combination of systems. The survey contained only data of 1,703 producers; 33 missing data on number of tillage passes (1,703–33=1,670).

In term of proportions, 71 percent are multisystem farmers and 29 percent are unisystem tillage farmers. Investigations on the proportions of land that farmers of only one tillage system versus those that combine more than one system are shown in table II-7. An average of 736 acres were planted to annual crops by unisystem producers versus 1,116 acres planted to annual on average by a multisystem producer. There was a difference between actual results shown in table II-7 and implications from the same results which might be due to inconsistency in producers' responses (1,050 versus 443) or even from missing values (620 versus 1,108). By comparing table II-7 to table II-3, there was not much difference considering the response inconsistency and missing values generated in the survey. For unisystem producers, average acres reported were respectively 707 acres and 736 in table II-3 and table II-7, and the number of respondents was 1,113 and 1,108 respectively in table II-3 and table II-7. For multisystem producers, average acres reported were respectively 1,164 acres and 1,116 in table II-3 and table II-7, and the number of respondents was 582 and 443 respectively in table II-3 and table II-7.

Table II-7 Number of tillage passes and acres farmed by producers of only one tillage system and those of more than one tillage system

Item	Mean	Std Dev	Respondents
Intensive tillage [a]	3.8[b]	1.3	1,180[c]
Reduced tillage [d]	2.1	1.2	849
Conservation tillage [e]	0.5	0.9	691
Average acres planted by respondents that are using one tillage system or more than one tillage system			
Unisystem	736 acres		1,108
Multisystem	1,116 acres		443

[a] This includes several tillage passes and leaves less than 15 percent of residue on the soil surface after planting.
[b] Respondents reported an average of three and four fifth tillage passes when using intensive tillage .
[c] A total of 1,180 respondents reported the number of tillage passes when using intensive tillage.
[d] This includes one to three full width tillage passes and leaves 15-30 percent of residue on the soil surface after planting.
[e] Minimum soil disturbance; practices that fall under conservation tillage included strip-till, ridge-till, and vertical-till.
[f] Producers that reported they planted all their crop acres using only one of the three tillage categories.
[g] Producers are those that plant acres using more than one tillage system as defined on the survey.

Farmers were asked to report the number of years they used their current tillage practices. The average years reported by respondents is four and half years (table II-8).

Table II-8. Number of years, farmers used their current tillage practice

Mean	Std Dev	Number
4.5[a]	1.0	1,650[b]

[a]: Respondents in our survey reported they had been using their current tillage method for an average of four and half years.
[b]: A total of 1,650 farmers surveyed responded to the number of years they had been using their current tillage method.

Producers were asked to report whether they tried a form of CST and switched back to IT. A number of 293 farmers answered YES, indicating that they tried a form of CST but then returned to IT (table II-9).

Table II-9. Number of producers that switched from conservation tillage to intensive tillage

Yes	No
293[a]	1,291[b]

[a] 293 respondents reported they tried conservation tillage practice before, and then switched back to intensive tillage.
[b] The 1,291 farmers that answered NO probably answered no they did not try a form of conservation tillage at all.

Of the producers that answered YES they tried CST and switched back to IT in table II-10a, 33 percent use IT exclusively, 65 percent use other tillage type (OT), and two percent use CST exclusively (table II-10). The notion of exclusivity used to categorize the tillage groups refer to pure users of a tillage method. For instance, IT exclusively is the category of producers that reported planting all of their crop acres using IT system, and those that planted all of their acres using CST are under CST exclusive category. Producers that did not use either of the two systems exclusively are grouped in other tillage type (OT) category.

Table II-10. Producers that reported they tried conservation tillage and switched back to intensive tillage

		Intensive tillage exclusively [a]	Conservation tillage exclusively [b]	Other tillage [c]	
	Respondents	458	93	740	1291
NO	Percent	35%	7%	57%	81%
	Respondents	96	7	190	293
YES	Percent	33%	2%	65%	18%

[a] Farmers that reported they planted all their crop acres using intensive tillage exclusively.
[b] Farmers that reported they planted all their crop acres using conservation tillage exclusively.
[c] Farmers that did not use intensive tillage exclusively and did not use conservation tillage exclusively.

Producers were asked to report the number of years they tried CST before switching back to IT. The average number of years reported by producers that used CST before switching to IT was 2.4 years (table II-11). Difference between the 293 reported in table II-10 and the 278 in table II-11 is due to nonresponse issues.

Table II-11. Number of years using conservation tillage before switching to intensive tillage

Mean	Std Dev	Number
2.4[a]	1.4	278[b]

[a] Respondents that tried conservation tillage before and switched back to intensive tillage used conservation tillage for 2.4 years (29 months) on average.

Farmers were asked about their perception of the benefits of CST practices; they were given the possibility that CST reduces labor costs, reduces fuel costs, reduces equipment costs, reduces soil erosion, increases yield, generates greater profits, conserves soil moisture, reduces soil compaction, and improves ecological diversity. The perceived benefits of CST practices were rated between one to eight, one being he (farmer) strongly disagrees with the statement about the perception of CST practices and eight being he (farmer) strongly agrees with the statement about the perception of CST practices. The mean values on the perceived benefits of CST s are reported in the table II-12.

Table II-12. Perceived benefits of conservation tillage practices (1-8; 1 = strongly disagree; 8 strongly agree)

Item	Mean [a]	Std Dev	Number [b]
Reduces labor costs	7	2	1,559
Reduces fuel costs	7	1	1,594
Reduces equipment costs	6	2	1,561
Reduces soil erosion	7	2	1,584
Increases yield	4	2	1,513
Generates greater profits	5	2	1,518
Conserves soil moisture	6	2	1,550
Reduces soil compaction	5	2	1,537
Improves ecological diversity	6	2	1,464
Intensive tillage exclusively [c]			
Reduces labor costs	6	2	506
Reduces fuel costs	7	2	516
Reduces equipment costs	5	2	502
Reduces soil erosion	6	2	514
Increases yield	3	2	490
Generates greater profits	4	2	487
Conserves soil moisture	6	3	501
Reduces soil compaction	5	2	498
Improves ecological diversity	5	2	479
Conservation tillage exclusively [d]			
Reduces labor costs	8	1	114
Reduces fuel costs	8	1	114
Reduces equipment costs	7	2	114
Reduces soil erosion	8	1	114
Increases yield	5	2	109
Generates greater profits	6	2	114
Conserves soil moisture	7	1	114
Reduces soil compaction	7	2	114
Improves ecological diversity	7	2	112

[a] On a scale from one to eight, the mean reported on perceived knowledge of conservation tillage practices by farmers surveyed.
[b] The number of farmers that responded to the corresponding item.
[c] Farmers that reported they planted all their crop acres using intensive tillage exclusively.
[d] Farmers that reported they planted all their crop acres using conservation tillage exclusively.

In table II-13 the rating scores were divided in five categories: “1”, category that reported they strongly disagree with the statement; “2-3”, category that reported their perceived benefits of CST to be two or three; “4-5”, category that reported their perceived benefits of CST to be four or five; “6-7”, category that reported their perceived benefits of CST to be six or seven; “8”, category that reported they strongly agree with the statement (table II-13).

Table II-13. Rating of perceived benefits of conservation tillage practices

	1-8; 1 = strongly disagree; 8 strongly agree					
Item	**1**	**2-3**	**4-5**	**6-7**	**8**	**Number** [a]
Reduces labor costs	2%[b]	3%	13%	35%	46%	1,558
Reduces fuel costs	2%	2%	11%	34%	51%	1,593
Reduces equipment costs	6%	11%	22%	27%	34%	1,561
Reduces soil erosion	3%	4%	13%	33%	47%	1,583
Increases yield	13%	23%	44%	15%	5%	1,512
Generates greater profits	9%	15%	43%	21%	11%	1,517
Conserves soil moisture	3%	6%	20%	39%	32%	1,547
Reduces soil compaction	7%	14%	28%	32%	18%	1,537
Improves ecological diversity	4%	8%	38%	30%	20%	1,461
Intensive tillage exclusively [c]						
Reduces labor costs	5%	6%	17%	40%	34%	506
Reduces fuel costs	3%	3%	14%	38%	42%	516
Reduces equipment costs	9%	15%	24%	26%	26%	502
Reduces soil erosion	6%	7%	18%	36%	33%	514
Increases yield	0%	35%	34%	25%	6%	490
Generates greater profits	17%	23%	43%	14%	4%	487
Conserves soil moisture	6%	9%	26%	39%	20%	501
Reduces soil compaction	13%	17%	31%	27%	12%	498
Improves ecological diversity	9%	11%	45%	24%	11%	479
Conservation tillage exclusively [d]						
Reduces labor costs	0%	1%	1%	23%	75%	114
Reduces fuel costs	0%	0%	3%	18%	79%	114
Reduces equipment costs	2%	3%	18%	20%	58%	114
Reduces soil erosion	1%	2%	4%	13%	81%	114
Increases yield	0%	4%	22%	55%	19%	109
Generates greater profits	2%	2%	30%	40%	26%	114
Conserves soil moisture	0%	0%	4%	29%	67%	114
Reduces soil compaction	2%	1%	16%	37%	45%	114
Improves ecological diversity	3%	2%	14%	31%	50%	112

[a] The number of farmers that responded to the corresponding item.
[b] On a scale from one to eight, two percent of the 1,558 farmers that responded strongly disagreed (rate=1) that conservation tillage practice reduces labor costs.
[c] Farmers that reported they planted all their crop acres using intensive tillage exclusively.
[d] Farmers that reported they planted all their crop acres using conservation tillage exclusively.

Producers that rated eight, on a scale from zero to eight, that CST generates greater profits in table II-13 are expected to use these practices. A rational producer will use the tillage practice that maximizes profits; therefore greater profits will be associated with the likelihood of using the tillage practice. Previous studies on the economics of CST especially no-till in Oklahoma have found that on smaller farm size IT was more economical for continuous monoculture wheat systems (Epplin and Tice 1986; Epplin et al. 2005; Decker et al. 2009). Of the 11 percent that rated eight, CST generates greater profits, only a fifth are still using CST methods exclusively (19 percent); 11 percent are using IT exclusively; and the remaining 70 percent are using other tillage or a combination of the systems (table II-14).

Table II-14. Producers that rated eight, CST generates greater profits

	Intensive tillage exclusively [a]	**Conservation tillage exclusively** [b]	**Other tillage** [c]
Respondents	18	30	114
Percent	11%	19%	70%

[a] Farmers that reported they planted all their crop acres using intensive tillage exclusively.
[b] Farmers that reported they planted all their crop acres using reduced tillage exclusively.
[c] Farmers that did not use intensive tillage exclusively and did not use conservation tillage exclusively.

Few producers rated eight, on a scale from zero to eight, CST increases yields. Studies of continuous monoculture wheat systems in Oklahoma have found that on average IT wheat grain yield is greater than the yield of CST system (Daniel et al. 1956; Zingg and Whitfield 1957; Harper 1960; Davidson and Santelmann 1973; Heer and Krenzer 1989; Epplin et al. 1994; Epplin and Al-Sakkaf 1995; Decker et al. 2009). Of those that rated eight, CST increases yields, only 17 percent are using CST exclusively; 17 percent are using IT exclusively; and the remaining 67 percent are using other tillage type (table II-15).

Table II-15. Producers that rated eight, CST increases yields

	Intensive tillage exclusively [a]	Conservation tillage exclusively [b]	Other tillage [c]
Respondents	13	13	52
Percent	17%	17%	67%

[a] Farmers that reported they planted all their crop acres using intensive tillage exclusively.
[b] Farmers that reported they planted all their crop acres using conservation tillage exclusively.
[c] Farmers that did not use intensive tillage exclusively and did not use conservation tillage exclusively.

Farmers were asked about their perception of the problems that restrict CST practices; they were given the possibility of a lack of state/local research, an increase in weed pressure, soil fertility issues, an increase in insect pressure, residue management issues, equipment costs, increased management skills, poor economic returns, a difficulty in getting a stand, an inappropriate soil type, grazing concerns, a reduction in yields, an uncooperative landlord, an increase in soil compaction, a lack of rental equipment, an increase in soil and plant disease, and a lack of knowledge of CST. The perceived problems of CST practices were rated between one to eight, one being he (farmer) strongly disagrees with the statement about the perception of CST practices and eight being he (farmer) strongly agrees with the statement about the perception of CST practices. The mean values on the perceived problems of CST s are reported in table II-16.

Table II-16. Perceived problems of conservation tillage practices (1-8; 1 = strongly disagree; 8 strongly agree)

Item	Mean	Std Dev	Number [a]
Lack of state/local research	5[b]	2	1,409
Increases weed pressure	6	3	1,514
Soil fertility issues	5	2	1,445
Increases insect pressure	6	2	1,468
Residue management	5	2	1,486
Equipment costs	6	2	1,513
Increased management skills	6	2	1,469
Poor economic returns	5	2	1,460
Difficulty in getting a stand	5	2	1,474
Inappropriate soil type	5	2	1,427
Grazing concerns	5	2	1,476
Reduces yields	5	2	1,462
Uncooperative landlord	4	2	1,312
Increases soil compaction	4	2	1,449
Lack of rental equipment	5	2	1,373
Increases soil and plant disease	5	2	1,440
Lack of knowledge of conservation tillage	5	2	1,497
Intensive tillage exclusively [c]			
Lack of state/local research	4	2	444
Increases weed pressure	6	2	491
Soil fertility issues	5	2	462
Increases insect pressure	6	2	475
Residue management	6	2	480
Equipment costs	6	2	486
Increased management skills	5	2	467
Poor economic returns	5	2	467
Difficulty in getting a stand	5	2	468
Inappropriate soil type	5	2	464
Grazing concerns	6	2	475
Reduces yields	5	2	468
Uncooperative landlord	4	2	419
Increases soil compaction	5	2	467
Lack of rental equipment	5	2	447
Increases soil and plant disease	6	2	459
Lack of knowledge of conservation tillage	5	2	487

Table II-16. Perceived problems of conservation tillage practices (1-8; 1 = strongly disagree; 8 strongly agree)

Item	Mean	Std Dev	Number [a]
Conservation tillage exclusively [d]			
Lack of state/local research	6	2	102
Increases weed pressure	4	2	106
Soil fertility issues	4	2	102
Increases insect pressure	4	2	105
Residue management	4	2	106
Equipment costs	5	2	107
Increased management skills	6	2	107
Poor economic returns	3	2	100
Difficulty in getting a stand	3	2	105
Inappropriate soil type	3	2	100
Grazing concerns	4	2	104
Reduces yields	3	2	103
Uncooperative landlord	4	2	95
Increases soil compaction	3	2	98
Lack of rental equipment	4	2	96
Increases soil and plant disease	4	2	101
Lack of knowledge of conservation tillage	6	2	106

[a] The number of farmers that responded to the corresponding item.
[b] On a scale from one to eight, the mean reported on perceived problems of conservation tillage practices by farmers surveyed is five.
[c] Farmers that reported they planted all their crop acres using intensive tillage exclusively.
[d] Farmers that reported they planted all their crop acres using conservation tillage exclusively.

In the table II-17 the rating scores were divided in five categories; “1”, category that reported they strongly disagree with the statement; “2-3”, category that reported their perceived problems of CST to be two or three; “4-5”, category that reported their perceived problems of CST to be four or five; “6-7” category that reported their perceived problems of CST to be six or seven; “8”, category that reported they strongly agree with the statement (table II-17).

Table II-17. Rating of perceived problems of conservation tillage practices

Item	1-8; 1 = strongly disagree; 8 strongly agree					
	1	2-3	4-5	6-7	8	Number [a]
Lack of state/local research	8%[b]	15%	43%	25%	10%	1,409
Increases weed pressure	6%	12%	24%	38%	19%	1,513
Soil fertility issues	7%	13%	41%	30%	10%	1,445
Increases insect pressure	5%	9%	30%	38%	17%	1,468
Residue management	6%	10%	32%	37%	16%	1,486
Equipment costs	6%	11%	27%	33%	23%	1,510
Increased management skills	5%	9%	30%	38%	18%	1,469
Poor economic returns	7%	18%	42%	24%	9%	1,459
Difficulty in getting a stand	10%	18%	35%	26%	11%	1,473
Inappropriate soil type	9%	14%	39%	26%	13%	1,425
Grazing concerns	8%	12%	29%	31%	20%	1,476
Reduces yields	8%	15%	37%	28%	12%	1,462
Uncooperative landlord	22%	19%	32%	18%	10%	1,311
Increases soil compaction	14%	20%	33%	23%	10%	1,449
Lack of rental equipment	12%	15%	35%	25%	13%	1,371
Increases soil and plant disease	8%	11%	32%	32%	17%	1,438
Lack of knowledge of conservation tillage	7%	13%	32%	29%	19%	1,495
Intensive tillage exclusively [c]						
Lack of state/local research	10%	16%	47%	22%	6%	444
Increases weed pressure	5%	9%	23%	38%	25%	491
Soil fertility issues	5%	10%	43%	31%	11%	462
Increases insect pressure	4%	6%	29%	39%	23%	475
Residue management	3%	8%	32%	38%	19%	480
Equipment costs	6%	9%	26%	32%	27%	486
Increased management skills	6%	11%	33%	36%	14%	467
Poor economic returns	4%	11%	43%	28%	14%	467
Difficulty in getting a stand	5%	14%	35%	29%	17%	468
Inappropriate soil type	5%	9%	39%	28%	19%	464
Grazing concerns	5%	11%	29%	29%	25%	475
Reduces yields	4%	10%	38%	28%	19%	468
Uncooperative landlord	23%	17%	34%	15%	11%	419
Increases soil compaction	10%	14%	37%	23%	16%	467
Lack of rental equipment	11%	13%	34%	26%	16%	447
Increases soil and plant disease	5%	7%	33%	32%	23%	459
Lack of knowledge of conservation tillage	8%	16%	32%	25%	18%	487

Table II-17. Rating of perceived problems of conservation tillage practices

Item	1-8; 1 = strongly disagree; 8 strongly agree					
	1	2-3	4-5	6-7	8	Number [a]
Conservation tillage exclusively [d]						
Lack of state/local research	7%	11%	18%	38%	26%	102
Increases weed pressure	19%	21%	26%	25%	9%	106
Soil fertility issues	21%	27%	29%	19%	4%	102
Increases insect pressure	15%	28%	30%	20%	8%	105
Residue management	16%	22%	29%	28%	5%	106
Equipment costs	11%	21%	31%	25%	12%	107
Increased management skills	7%	6%	21%	40%	27%	107
Poor economic returns	29%	36%	24%	9%	2%	100
Difficulty in getting a stand	36%	30%	22%	10%	3%	105
Inappropriate soil type	36%	25%	30%	7%	2%	100
Grazing concerns	18%	22%	27%	23%	10%	104
Reduces yields	27%	32%	22%	17%	2%	103
Uncooperative landlord	28%	22%	24%	21%	4%	95
Increases soil compaction	43%	27%	18%	8%	4%	98
Lack of rental equipment	21%	16%	34%	23%	6%	96
Increases soil and plant disease	21%	28%	20%	25%	7%	101
Lack of knowledge of conservation tillage	9%	7%	24%	25%	36%	106

[a] The number of farmers that responded to the corresponding item.
[b] On a scale from one to eight, eight percent of the 1,409 farmers that responded strongly disagreed (rate=1) that the lack of a state/local research as a perceived problem of conservation tillage practice.
[c] Farmers that reported they planted all their crop acres using intensive tillage exclusively.
[d] Farmers that reported they planted all their crop acres using conservation tillage exclusively.

Farmers were asked to list the sources of information they consider to be useful in receiving information on CST practices. They were given the possibility of county extension meeting, bus tours, equipment dealers, field days, state-wide meetings, regional meetings, fact sheets, mass media, e-mail, and video conference websites. The perception on the source of information of CST practices were rated between one and eight, one being the source of information is not useful and eight being the source of information is very useful. The mean values on the perceived sources of information on CST practices are reported in table II-18.

Table II-18. Source of information of conservation tillage practices (1-8; 1=Not useful; 8=Very useful)

Item	Mean	Std Dev	Number [a]
County extension meeting	6[b]	2	1,475
Bus tours	5	2	1,379
Equipment dealers	5	2	1,407
Field days	6	2	1,448
State-wide meetings	5	2	1,391
Regional meetings	5	2	1,404
Fact sheets	6	2	1,457
Mass media	5	2	1,404
E-mail	4	2	1,363
Video conference websites	4	2	1366
Intensive tillage exclusively [c]			
County extension meeting	6	2	481
Bus tours	5	2	451
Equipment dealers	5	2	458
Field days	6	2	469
State-wide meetings	5	2	457
Regional meetings	5	2	463
Fact sheets	6	2	473
Mass media	5	2	452
E-mail	4	2	448
Video conference websites	4	2	450
Conservation tillage exclusively [d]			
County extension meeting	6	2	105
Bus tours	5	2	91
Equipment dealers	5	2	103
Field days	6	2	105
State-wide meetings	5	2	97
Regional meetings	6	2	98
Fact sheets	6	2	104
Mass media	5	2	102
E-mail	4	2	94
Video conference websites	4	2	95

[a] The number of farmers that responded to the corresponding item.
[b] On a scale from one to eight, the mean reported on useful sources of information on conservation tillage practices by farmers surveyed is six.
[c] Farmers that reported they planted all their crop acres using intensive tillage exclusively.
[d] Farmers that reported they planted all their crop acres using conservation tillage exclusively.

In table II-19 the rating scores were divided in five categories; “1”, category that reported the source of information on CST practices is not useful; “2-3”, category that reported the source of information on CST practices to be two or three; “4-5”, category that reported the source of information on CST practices to be four or five; “6-7” category that reported the source of information on CST practices to be six or seven; “8”, category that reported the source of information on CST practices is very useful (table II-19).

Table II-19. Rating of source of information on conservation tillage practices

	1-8; 1=Not useful; 8=Very useful					
Item	**1**	**2-3**	**4-5**	**6-7**	**8**	**Number [a]**
County extension meeting	6%[b]	8%	22%	37%	26%	1,474
Bus tours	13%	17%	36%	23%	11%	1,377
Equipment dealers	11%	15%	39%	26%	9%	1,406
Field days	5%	7%	24%	41%	24%	1,447
State-wide meetings	10%	15%	37%	27%	12%	1,390
Regional meetings	9%	11%	34%	32%	13%	1,403
Fact sheets	4%	6%	25%	41%	23%	1,456
Mass media	10%	18%	36%	25%	11%	1,403
E-mail	24%	23%	30%	16%	7%	1,362
Video conference websites	24%	22%	32%	16%	7%	1,365
Intensive tillage exclusively [c]						
County extension meeting	6%	7%	23%	36%	28%	481
Bus tours	13%	18%	37%	21%	11%	451
Equipment dealers	10%	15%	39%	25%	10%	458
Field days	6%	8%	26%	38%	22%	469
State-wide meetings	11%	15%	39%	25%	10%	457
Regional meetings	10%	13%	35%	29%	12%	463
Fact sheets	6%	7%	27%	39%	21%	473
Mass media	10%	17%	38%	24%	11%	452
E-mail	27%	21%	30%	13%	8%	448
Video conference websites	27%	21%	30%	14%	7%	450

Table II-19. Rating of source of information on conservation tillage practices

Item	1-8; 1=Not useful; 8=Very useful					Number [a]
	1	2-3	4-5	6-7	8	
Conservation tillage exclusively [d]						
County extension meeting	11%	6%	19%	42%	22%	105
Bus tours	18%	18%	27%	25%	12%	91
Equipment dealers	16%	17%	30%	26%	11%	103
Field days	5%	8%	10%	43%	34%	105
State-wide meetings	7%	10%	27%	39%	16%	97
Regional meetings	5%	8%	19%	45%	22%	98
Fact sheets	3%	12%	26%	37%	23%	104
Mass media	13%	23%	27%	25%	12%	102
E-mail	23%	29%	19%	21%	7%	94
Video conference websites	26%	21%	26%	18%	8%	95

[a] The number of farmers that responded to the corresponding item.
[b] On a scale from one to eight, six percent of the 1,474 farmers that responded that county extension meeting is not a useful source of information on conservation tillage practices.
[c] Farmers that reported they planted all their crop acres using intensive tillage exclusively.
[d] Farmers that reported they planted all their crop acres using conservation tillage exclusively.

Producers were asked to report the areas which they consider to be appropriate topics for CST research focus. They were given the possibility of variety development, grazing management, rotational crops, soil compaction, weed control, equipment selection, and soil fertility. The perception on the areas which they consider to be appropriate topics for CST research were rated between one to eight, one being the topic of research is not appropriate and eight being the topic of research is appropriate. The mean values are reported in table II-20.

Table II-20. Areas on which conservation tillage research should focus (1-8; 1=Not appropriate; 9=Appropriate)

Item	Mean	Std Dev	Number [a]
Variety development	6[b]	2	1,419
Grazing management	7	2	1,444
Rotational crops	7	2	1,452
Soil compaction	6	2	1,446
Weed control	7	2	1,492
Equipment selection	6	2	1,451
Soil fertility	7	2	1,461
Intensive tillage exclusively [c]			
Variety development	6	2	452
Grazing management	6	2	455
Rotational crops	6	2	454
Soil compaction	6	2	454
Weed control	7	2	480
Equipment selection	6	2	460
Soil fertility	6	2	461
Conservation tillage exclusively [d]			
Variety development	7	2	105
Grazing management	7	2	107
Rotational crops	7	1	110
Soil compaction	7	2	106
Weed control	7	1	108
Equipment selection	7	2	106
Soil fertility	7	1	111

[a] The number of farmers that responded to the corresponding item.
[b] On a scale from one to eight, the mean reported on conservation tillage research should focus on variety development is six.
[c] Farmers that reported they planted all their crop acres using intensive tillage exclusively.
[d] Farmers that reported they planted all their crop acres using conservation tillage exclusively.

Table II-21. Rating of what area conservation tillage research should focus

Item	1-8; 1=Not appropriate; 8=Appropriate					Number[a]
	1	2-3	4-5	6-7	8	
Variety development	2%[b]	4%	19%	40%	34%	1,414
Grazing management	3%	3%	16%	41%	37%	1,440
Rotational crops	2%	3%	14%	42%	38%	1,447
Soil compaction	3%	4%	20%	40%	33%	1,442
Weed control	2%	2%	9%	41%	46%	1,489
Equipment selection	2%	3%	20%	43%	32%	1,448
Soil fertility	2%	2%	15%	43%	39%	1,457
Intensive tillage exclusively[c]						
Variety development	4%	6%	21%	38%	31%	452
Grazing management	4%	5%	17%	43%	32%	455
Rotational crops	3%	4%	17%	44%	32%	454
Soil compaction	3%	5%	21%	40%	31%	454
Weed control	3%	4%	10%	40%	43%	480
Equipment selection	3%	4%	20%	46%	27%	460
Soil fertility	3%	4%	18%	45%	30%	461
Conservation tillage exclusively[d]						
Variety development	3%	6%	12%	30%	49%	105
Grazing management	4%	2%	18%	35%	42%	107
Rotational crops	0%	2%	4%	30%	65%	110
Soil compaction	3%	3%	18%	36%	41%	106
Weed control	1%	2%	3%	38%	56%	108
Equipment selection	1%	3%	21%	33%	42%	106
Soil fertility	0%	0%	9%	31%	60%	111

[a] The number of farmers that responded to the corresponding item.
[b] On a scale from one to eight, two percent of the 1,414 farmers that responded reported that it is not appropriate for conservation tillage research to focus on variety development.
[c] Farmers that reported they planted all their crop acres using intensive tillage exclusively.
[d] Farmers that reported they planted all their crop acres using conservation tillage exclusively.

In table II-21 the rating scores were divided in five categories; “1”, category that reported the topic of research is not appropriate; “2-3”, “4-5”, “6-7”, and “8”, category that reported the topic of research is appropriate. Producers reported the existence of a viable crop to rotate mostly wheat with to be of a big concern. Three fifth of producers that rated the focus of CST for crop rotation, rated seven or eight, eight being the maximum. Weed control is one the biggest challenges CST producers face. Only 11 percent of the producers checked seven or eight, eight being the maximum, that weed control should be a the focus of CST research (table II-21).

Producers were asked to indicate the number of tractors they own of horsepower (HP) less than 125 HP, of power between 125-175 HP, 176-225 HP, and of power greater than 225 HP. About 70 percent of farmers in the survey reported they owned at least one tractor with less than 125 HP, 65 percent owned tractors of power between 126 and 175 HP, and 59 percent reported they own tractors of power greater than 176 HP (table II-22).

Table II-22. Farmers that reported ownership of tractors of various sizes

Power of tractors	**Respondents**	**Percent**
125 HP or less	1,193[a]	70%[a]
126-175 HP	1,113	65%
176-225 HP	462	27%
over 225 HP	550	32%

[a] A total of 1,193 producers (70%) responded they owned tractors of less than 125 HP.

Table II-23 includes a summary of the percent of farmers that reported ownership of tractors, the number of tractors they owned, and the power of the tractors.

Table II-23. Percent of farmers that reported ownership of tractors-

Item	Number of tractors owned				Respondents
	1	2	3	4+	
125 HP or less	49%[a]	30%	13%	9%	1,193[b]
126-175 HP	64%	26%	8%	2%	1,113
176-225 HP	70%	24%	5%	1%	462
over 225 HP	72%	22%	4%	2%	550

HP: Horse power
[a] 49 percent of the 1,193 that responded the item owned only one tractor 125 HP or less.
[b] A total of 1,193 farmers (70 percent of the survey respondents) reported ownership of at least one tractor of horse power equal to 125 or less.

Producers were asked to report the number of implements they currently use in their tillage operations. Table II-24 summarizes the percent of producers that answered using an implement in tillage operations.

Table II-24. Implements used in tillage operations

Item	Respondents	Percent
Tandem Disk	880[a]	52%[a]
Offset Disk	976	57%
Chisel Plow	1,310	77%
Sweep Plow	721	42%
Moldboard plow	739	43%
Field Cultivator	1,005	59%
Strip-till unit	60	4%
Vertical till	66	4%
Other	180	11%

[a] 52 percent (880) of farmers reported they used at least one tandem disk in their tillage operations

Table II-25. Number of implements owned under intensive tillage exclusively, conservation tillage exclusively, and other tillage methods.

	Number of implements	Intensive tillage exclusively [a]	Conservation tillage exclusively [b]	Other Tillage [c]	Total
Tandem Disk	1	79%	82%	73%	75%
	2	18%	6%	22%	20%
	3	3%	0%	4%	4%
	4	0%	12%	1%	1%
	% of tillage category	52%	15%	56%	
Offset Disk	1	77%	100%	77%	77%
	2	20%	0%	19%	19%
	3	2%	0%	3%	3%
	4	0%	0%	1%	1%
	% of tillage category	85%	13%	76%	
Chisel Plow	1	72%	75%	73%	72%
	2	24%	17%	23%	23%
	3	4%	0%	3%	4%
	4	0%	8%	1%	1%
	% of tillage category	87%	10%	79%	
Sweep Plow	1	80%	60%	78%	78%
	2	17%	40%	17%	17%
	3	3%	0%	4%	3%
	4	0%	0%	1%	1%
	% of tillage category	49%	4%	43%	
Moldboard Plow	1	71%	43%	69%	70%
	2	22%	43%	21%	21%
	3	5%	0%	6%	6%

Table II-25. Number of implements owned under intensive tillage exclusively, conservation tillage exclusively, and other tillage methods.

	Number of implements	Intensive tillage exclusively [a]	Conservation tillage exclusively [b]	Other Tillage [c]	Total
	4	3%	14%	4%	3%
	% of tillage category	59%	6%	39%	
Field Cultivator	1	79%	67%	80%	79%
	2	19%	22%	16%	17%
	3	3%	0%	3%	2%
	4	0%	11%	1%	1%
	% of tillage category	68%	8%	60%	
Strip Till Unit	1	100%	100%	89%	92%
	2	0%	0%	9%	7%
	4	0%	0%	0%	0%
	% of tillage category	2%	3%	5%	
Vertical Till	1	94%	75%	89%	89%
	2	6%	25%	7%	8%
	3	0%	0%	4%	3%
	% of tillage category	3%	3%	4%	
Other tillage implements	1	84%	92%	82%	84%
	2	12%	8%	13%	12%
	3	2%	0%	2%	2%
	4	2%	0%	2%	2%
	% of tillage category	7%	10%	12%	

[a] Pure users of intensive tillage . Producers in this category reported they planted all their annual crop acres using intensive tillage.
[b] Pure users of conservation tillage . Producers in this category reported they planted all their annual crop acres using conservation tillage.
[c] Farmers that did not use intensive tillage exclusively and did not use conservation tillage exclusively.

Table II-26. Average acres, number of respondents, total acres and proportion of acres by implements used in tillage operations.

Implements		Intensive tillage exclusively [a]	Conservation tillage exclusively [b]	Other tillage [c]	Total
Tandem Disk	Average [d]	588	922	999	
	Respondents [e]	303	17	556	
	Total [f]	178,033	15,672	555,366	749,071
	% of tillage category [g]	24%	2%	74%	15%
Offset Disk	Average	572	1104	800	
	Respondents	406	9	557	
	Total	232,356	9,939	445,434	687,729
	% of tillage category	34%	1%	65%	14%
Chisel Plow	Average	637	1058	996	
	Respondents	508	12	784	
	Total	323,375	12,692	781,109	1,117,177
	% of tillage category	29%	1%	70%	22%
Sweep Plow	Average	571	863	1069	
	Respondents	286	5	428	
	Total	163,432	4,315	457,592	625,339
	% of tillage category	26%	1%	73%	13%
Moldboard Plow	Average	653	558	934	
	Respondents	344	7	384	
	Total	224,776	3,904	358,706	587,386
	% of tillage category	38%	1%	61%	12%
Field Cultivator	Average	724	1234	955	
	Respondents	393	9	599	
	Total	284,386	11,104	571,927	867,417

Table II-26. Average acres, number of respondents, total acres and proportion of acres by implements used in tillage operations.

Implements		Intensive tillage exclusively [a]	Conservation tillage exclusively [b]	Other tillage [c]	Total
	% of tillage category	33%	1%	66%	17%
Strip Till Unit	Average	781	1298	1411	
	Respondents	10	4	46	
	Total	7,810	5,191	64,904	77,905
	% of tillage category	10%	7%	83%	2%
Vertical Till	Average	752	634	1289	
	Respondents	17	4	45	
	Total	12,782	2,535	58,003	73,320
	% of tillage category	17%	3%	79%	1%
Other tillage implements	Average	576	1097	1223	
	Respondents	43	12	125	
	Total	24,771	13,166	152,854	190,791
	% of tillage category	13%	7%	80%	4%

[a] Respondents in this category reported they planted all of their annual crop acres using intensive tillage.
[b] Respondents in this category reported they planted all of their annual crop acres using conservation tillage.
[c] Respondents that did not use intensive tillage exclusively and did not use conservation tillage exclusively.
[d] The average number of acres planted to annual crops using the corresponding implement.
[e] The number of respondents that reported using an implement under one of the tillage practices.
[f] The total number of acres planted to annual crops using the corresponding implement.
The sum of the total acres across all implements (4,976,135 acres) is greater than the total acres planted to annual crops in the survey (1,463,699 acres). For instance, the same producer could be using three different implements for the same tillage practice; therefore the number of acres reported will be counted for each of the implements. However, in term of proportion of acres, there is more accuracy and no replication.
[g] The percent of acres using the corresponding implement.

Table II-27 reports the number of implements producers used in their tillage operations, and the percent of producers that use the implement.

Table II-27. Number of implements used in tillage operations

Item	Number of implements in tillage operation 1	2	3	4+	Number
Tandem Disk	75%[a]	20%	4%	1%	880
Offset Disk	77%	19%	3%	1%	976
Chisel Plow	72%	23%	4%	1%	1,310
Sweep Plow	78%	17%	3%	1%	721
Moldboard plow	70%	21%	6%	3%	739
Field Cultivator	79%	17%	2%	1%	1,005
Strip-till unit	92%	7%	0%	2%	60
Vertical till	89%	8%	3%	0%	66
Other	83%	12%	2%	2%	180

[a] 75 percent of the 880 farmers reported they used one tandem disk in tillage operations.

Producers were asked to report the number of implements they currently use in their planting operations. Table II-28 summarizes the percent of producers that answered using an implement in planting operations.

Table II-28. Implements used in planting operations

Item	Respondents	Percent
Air Seeder	195[a]	11%[a]
Row Crop Planter	396	23%
Double Disk Drill	1,041	61%
Single Disk Drill	577	34%
Hoe Drill	152	9%

[a] 11 percent (195) of farmers reported they used at least one air seeder in their planting operations.

Table II-29 summarizes the number of implements producers used in producers' planting operations, and the percent of producers that use the implement.

Table II-29. Number of implements used in planting operations

Item	Number of implements in planting operations				Number
	1	2	3	4+	
Air Seeder	94%[a]	5%	1%	1%	195
Row Crop Planter	92%	7%	1%	1%	396
Double Disk Drill	77%	19%	3%	1%	1,041
Single Disk Drill	72%	21%	5%	2%	577
Hoe Drill	79%	14%	5%	3%	152

[a] 94 percent of the 195 farmers reported they used only one air seeder in their planting operations.

Table II-30. Number of planting implements used under intensive tillage exclusively, conservation tillage exclusively, and other tillage methods.

	Number of implements	Intensive tillage exclusively [a]	Conservation tillage exclusively [b]	Other Tillage [c]	Total
Air Seeder	1	86%	89%	96%	94%
	2	9%	8%	3%	5%
	3	5%	0%	1%	1%
	4	0%	3%	0%	1%
	% of tillage category	4%	31%	14%	
Row Crop Planter	1	94%	94%	91%	92%
	2	6%	4%	7%	6%
	3	0%	0%	1%	1%
	4	0%	2%	1%	1%
	% of tillage category	26%	70%	48%	
Double Disk Drill	1	74%	96%	77%	77%
	2	20%	4%	18%	19%
	3	3%	0%	3%	3%
	4	2%	0%	1%	1%
	% of tillage category	61%	42%	63%	
Single Disk Drill	1	71%	90%	72%	72%
	2	23%	0%	21%	21%
	3	5%	0%	6%	5%
	4	2%	10%	1%	2%
	% of tillage category	38%	4%	58%	100%
Hoe Drill	1	73%	100%	82%	79%
	2	17%	0%	13%	14%
	3	5%	0%	5%	5%
	4	5%	0%	1%	3%
	% of tillage category	38%	18%	33%	

Producers were asked to report the number of other implements they currently use in their production operations. Table II-31 is a report of the percent of producers that answered using an implement in the production system.

Table II-31. Other implements used in the production system

Item	Respondents	Percent
Anhydrous Applicator	444[a]	26%[a]
Combine	1,073	63%
Sprayer	1,071	63%
Fertilizer Spreader (dry)	579	34%
Fertilizer Spreader (wet)	292	17%

[a] 26 percent (444) of farmers reported they used at least one anhydrous applicator in the production system.

Table II-32. Other implements used under intensive tillage exclusively, conservation tillage exclusively, and other tillage methods.

	Number of implements	Intensive tillage exclusively [a]	Conservation tillage exclusively [b]	Other Tillage [c]	Total
Anhydrous Applicator	1	89%	88%	93%	91%
	2	10%	0%	4%	6%
	3	0%	13%	2%	1%
	4	2%	0%	0%	1%
	% of tillage category	29%	7%	27%	
Combine	1	72%	81%	70%	72%
	2	22%	14%	23%	22%
	3	4%	1%	4%	4%
	4	2%	4%	2%	2%
	% of tillage category	76%	81%	78%	
Sprayer	1	93%	91%	89%	90%
	2	6%	9%	8%	7%
	3	0%	0%	2%	2%
	4	0%	0%	1%	0%
	% of tillage category	50%	85%	68%	
Fertilizer Spreader (dry)	1	96%	95%	93%	94%
	2	3%	5%	5%	4%
	3	1%	0%	1%	1%
	4	1%	0%	1%	1%
	% of tillage category	32%	36%	35%	
Fertilizer Spreader (wet)	1	100%	100%	94%	96%
	2	0%	0%	4%	3%
	3	0%	0%	0%	0%
	4	0%	0%	1%	1%
	% of tillage category	11%	21%	20%	

[a] Respondents in this category reported they planted all of their annual crop acres using intensive tillage.
[b] Respondents in this category reported they planted all of their annual crop acres using conservation tillage.
[c] Respondents that did not use intensive tillage exclusively and did not use conservation tillage exclusively.

Table II-33 summarizes the hypothesis testing for the proportions of different implements reported by IT and CST producers. A positive significant sign on the t-value implies that the proportion of IT producers that reported using an item is greater than the proportion of CST producers that use the same item (IT>CST). For instance, in table II-32, 11 percent of the IT producers use a wet fertilizer spreader and alternatively 21 percent of CST farmers reported using the same item (table II-32). The hypothesis is that the proportion of CST producers that use a wet fertilizer spreader is greater than the proportion of IT producers that use a wet fertilizer spreader. The test statistics results suggest that the proportion of IT producers that use a wet fertilizer spreader is less than the proportion of CST producers that use a wet fertilizer spreader (CST>IT or IT<CST). The IT group is more likely to use a tandem disk, an offset disk, a chisel plow, a sweep plow, a moldboard plow, a field cultivator, a single and a double disk drill, a hoe drill, and an anhydrous applicator than the CST group; the CST group uses more likely than the IT group an air seeder, a row crop planter, a sprayer, and a wet fertilizer spreader (table II-33).

Table II-33. Test Statistics for the proportions of implements used in the production system across tillage categories

Items	t-value	Pr > |t|	Conclusion
Tandem Disk	9.69	<.0001	IT>CST
Offset Disk	15.69	<.0001	IT>CST
Chisel Plow	23.12	<.0001	IT>CST
Sweep Plow	16.04	<.0001	IT>CST
Moldboard plow	17.7	<.0001	IT>CST
Field Cultivator	19.02	<.0001	IT>CST
Strip-till unit	-0.96	0.3386	No evidence
Vertical till	-0.29	0.7739	No evidence
Air Seeder	-6.19	<.0001	CST>IT
Row Crop Planter	-7.36	<.0001	CST>IT
Double Disk Drill	3.93	<.0001	IT>CST
Single Disk Drill	4.93	<.0001	IT>CST
Hoe Drill	3.27	0.0012	IT>CST
Anhydrous Applicator	7.33	<.0001	IT>CST
Combine	-1.07	0.2852	No evidence
Sprayer	-9.2	<.0001	CST>IT
Fertilizer Spreader (dry)	-0.75	0.4509	No evidence
Fertilizer Spreader (wet)	-2.53	0.0123	CST>IT

Table II-34 summarizes the number of other types of implements producers used in their production system, and the percent of producers that use the implement.

Table II-34. Number of other implements used in the production system

	Other implements used in the production system				
Item	**1**	**2**	**3**	**4+**	**Number**
Anhydrous Applicator	91%[a]	6%	1%	1%	444
Combine	71%	22%	4%	2%	1,073
Sprayer	90%	7%	2%	0%	1,071
Fertilizer Spreader (dry)	94%	4%	1%	1%	579
Fertilizer Spreader (wet)	96%	3%	0%	1%	292

[a] 91 percent of the 444 farmers that reported that they use an anhydrous applicator reported they used only one anhydrous applicator.

Surveyed farmers reported the primary purpose of their wheat production (table II-35). About a quarter (24 percent) of producers reported they seeded wheat for grain – only purpose, 13 percent of the farms for full season grazing (forage-only), and 64 percent of farms for dual-purpose (fall-winter grazing plus grain) (table II-35).

Table II-35. Wheat production systems (percent of farms)

	Grain-only [a]	**Forage-only** [b]	**Dual-purpose** [c] **(fall-winter grazing plus grain)**	**Respondents**
Number	396[d]	209	1059	1,664
Percent	24%[d]	13%	64%	

[a] Winter wheat planted for grain only purpose.
[b] Winter wheat planted for both fall-winter grazing and grain.
[c] Winter wheat planted for full season grazing or grazing plus hay.
[d] 396 farmers answered the primary purpose of their wheat grain is grain only purpose.

Producers were asked to respond "yes" or "no" to a question asking if livestock has a negative impact on the adoption of CST on small grain acres. Two fifths of producers that answered the question reported YES, livestock has a negative impact on the adoption of CST on small grain acres; while the remaining three fifths reported NO, livestock does not has a negative impact on the adoption of CST on small grain acres (table II-36).

Table II-36. Negative impact of livestock on conservation tillage for small grains

	Yes	**No**	**Respondents**
Number	595[a]	884	1,479
Percent	40%[a]	60%	

[a] 595 farmers answered YES, livestock negatively impacts the adoption of conservation tillage on small grain acres.

Producers were asked whether or not they graze their CST small grain acres. Half of farmers reported they graze their CST small grain for forage only purpose or for dual purpose (table II-37).

Table II-37. Graze conservation tillage small grain

	Yes	No	Respondents
Number	584[a]	582	1,166
Percent	50%[a]	50%	

[a] 584 farmers answered YES, they graze their conservation tillage small grain acres.

Producers were asked to report whether or not they practice a crop rotation (table II-38). Two fifths of producers that answered the question reported "yes", they practice a crop rotation system on their farm; while the remaining three fifth reported NO, they do not practice a crop rotation system (table II-38).

Table II-38. Cropping systems

	Yes (crop rotation) [a]	No (Monoculture) [b]	Respondents
Number	648[c]	972	1,620
Percent	40%[c]	60%	

[a] Culture of wheat followed by another crop than wheat.
[b] Culture of wheat year after year consecutively.
[c] 648 farmers answered YES, they practice a crop rotation.

Producers were asked to report their age group. Results are reported in table II-39. Only two farmers indicated that they were between 18 and 25. About three percent of the farmers were less than 34, six percent between 35 and 44, 22 percent between 45 and 54, 31 percent between 55 and 65, and the rest, 38 percent, were older than 65 (table II-39). The United States Department of Agriculture National Agricultural Statistics Service reported in 2007 an average age of operators in Oklahoma of 55.3 years (USDA/NASS 2007). According to the same report, about two percent of the operators were less than 25 years, seven percent between 25-34 years, 14 percent between 35-44 years, 24 percent between 45-54 years, 25 percent between 55-64 years and the remaining 28 percent are over 64 years (USDA/NASS 2007). The results reported in table II-39 are consistent with those reported by the USDA/NASS in 2007.

Table II-39. Age group

	18-25	26-34	35-44	45-54	55-65	65+	Respondents
Number	2[a]	43	108	360	517	643	1,673
Percent	0%[a]	3%	6%	22%	31%	38%	

[a] Two (2) farmers responded their age to be between 18 and 25.

Producers were asked to report their education level. Two percent reported grade school, 49 percent reported high school, 38 percent had a bachelor of science degree, eight percent reported a master's of science degree, and only two percent had a doctor of philosophy degree (table II-40).

Table II-40. Education level

	Grade school	High school	B.S	M.S.	Ph.D.	Respondents
Number	31[a]	811	638	138	40	1,658
Percent	2%[a]	49%	38%	8%	2%	

[a] 31 farmers reported their education level is equivalent to grade school.

Producers were asked to report the total crop and livestock sales in an average year. Half of farmers reported crop and livestock sales less than $100,000 a year on average. Only 11 percent reported over half a million dollars in crop and livestock sales in an average year. The remaining 29 percent and ten percent of farmers reported respectively crop and livestock sales between $100,000 and $250,000, and between $250,000 and $500,000 (table II-41).

Table II-41. Crop and Livestock sales

	0- 100,000	100,000-250,000	250,000-500,000	500,000-750,000	750,000-1,000,000	Over 1,000,000	Respondents
Number	778[a]	459	173	56	47	56	1,569
Percent	50%[a]	29%	10%	4%	3%	4%	

[a] 778 farmers (50%) responded their total crops and livestock sales in an average year is less than $100,000.

The approximate split of on-farm income between crop and livestock sales is fifty-fifty (table II-42).

Table II-42. Split of farm income between crop and livestock sales.

	Crop	Livestock
Percent	50%[a]	50%

[a] Producers surveyed reported that on average half of their farm income is from livestock sales.

About 14 percent of farmers reported that their on-farm income is exclusively from crop sales. A quarter of producers reported their on-farm income is between 51 percent and 99 percent from crop sales while 27 percent reported between 51 percent and 99 percent of their on-farm income from livestock sales. The rest (34 percent) reported a fifty-fifty split of on-farm income between crop and livestock sales (table II-43).

Table II-43. Split of on-farm income between crop and livestock sales.

Split between crop and livestock sales	Number	Proportion
Exclusive crops sales	229[a]	14%[a]
51 to 99 percent of crops sales	430	25%
Fifty-fifty sales	585	34%
51 to 99 percent of livestock sales	459	27%

[a] Fourteen percent of the respondents (229) reported their on-farm income is exclusively from crop sales.

Producers were asked to report the number of hours per week they work off-farm. The majority of farmers reported not working off-farm (62 percent). Only three percent work between one to five hours a week, two percent worked between six and ten hours a week and five percent reported between 11 and 20 hours. About 13 percent worked between 21 and 40 hours a week and 15 percent reported working over 40 hours a week (table II-44).

Table II-44 Off farm employment

	None	1-5	6-10	11-20	21-40	40+	Respondents
Number	1,036[a]	54	36	80	212	241	1,659
Percent	62%[a]	3%	2%	5%	13%	15%	

[a] 1,036 farmers reported they work zero hours off-farm.

Table II-45 Producers age categories and Off-farm employment

Age	Employment							
	0 hours	**1-5 hours**	**6-10 hours**	**11-20 hours**	**21-40 hours**	**Over 40 hours**	**Total**	**Percent**
18-25	1	1	0	0	0	0	2	0.1%
	0.1%	1.9%	0.0%	0.0%	0.0%	0.0%		
26-34	23	2	0	2	9	7	43	2.6%
	2.2%	3.7%	0.0%	2.5%	4.3%	2.9%		
35-44	47	4	4	5	21	27	108	6.6%
	4.6%	7.4%	11.4%	6.3%	10.0%	11.3%		
45-54	176	10	5	20	58	87	356	21.7%
	17.2%	18.5%	14.3%	25.0%	27.5%	36.4%		
55-65	282	17	15	31	82	83	510	31.0%
	27.5%	31.5%	42.9%	38.8%	38.9%	34.7%		
Over 65	496	20	11	22	41	35	625	38.0%
	48.4%	37.0%	31.4%	27.5%	19.4%	14.6%		
Total	1025	54	35	80	211	239		
Percent	62.4%	3.3%	2.1%	4.9%	12.8%	14.5%		

Table II-46 Producers age categories and Off-farm employment

	Employment							
Age	**0 hours**	**1-5 hours**	**6-10 hours**	**11-20 hours**	**21-40 hours**	**Over 40 hours**	**Total**	**Percent**
18-25	1	1	0	0	0	0	2	0.1%
	50%	50%	0%	0%	0%	0%		
26-34	23	2	0	2	9	7	43	2.6%
	53%	5%	0%	5%	21%	16%		
35-44	47	4	4	5	21	27	108	6.6%
	44%	4%	4%	5%	19%	25%		
45-54	176	10	5	20	58	87	356	21.7%
	49%	3%	1%	6%	16%	24%		
55-65	282	17	15	31	82	83	510	31.0%
	55%	3%	3%	6%	16%	16%		
Over 65	496	20	11	22	41	35	625	38.0%
	79%	3%	2%	4%	7%	6%		
Total	1025	54	35	80	211	239		
Percent	62.4%	3.3%	2.1%	4.9%	12.8%	14.5%		

Producers were asked to report the percentage of their income that is from off-farm (table II-47). Approximately, two-fifths of farmers reported that none of their income was from off-farm while a fifth reported off-farm income to represent 75 percent of their income. Respectively, ten percent, 13 percent and 17 percent reported 10 percent, 25 percent, and 50 percent of income is from off-farm (table II-47).

Table II-47 Percentage of income from off farm

	None	10 percent	25 percent	50 percent	75 percent	Respondents
Number	662[a]	167	214	280	303	1,626
Percent	41%[a]	10%	13%	17%	19%	

[a] 662 farmers reported they zero percent of their income is from off-farm.

Producers were asked to report the number of acres of cultivated land they rent in a typical year. On average the 1,166 producers rent 665 acres of land to produce annual crops (table II-48). A total of 537 producers (32 percent) out of the 1,703 in the survey did not report they rent land.

Table II-48 Rented land

Respondents	Mean	Std Dev
1,166[a]	665[b]	876

[a] 1,166 producers reported they rented some acres to produce annual crops.
[b] The average number of acres rented by the respondents is 665 acres to produce annual crops.

CHAPTER III

INTENSIVE TILLAGE VERSUS CONSERVATION TILLAGE: CHARACTERISTICS OF PRODUCERS AND FARMS

The objective reported in this part of the thesis is to determine the proportion of Oklahoma farmers that use IT (intensive tillage) exclusively, the proportion that use CST (conservation tillage) exclusively, and the proportion that do not use either IT or CST exclusively (other tillage (OT)). An additional objective is to determine characteristics of farms and farmers that fall into each of the three (IT exclusively, CST exclusively, OT) categories.

The respondents were classified into three categories: IT, respondents in this category reported they planted all of their annual crop acres using intensive tillage; CST, respondents in this category reported they planted all of their annual crop acres using conservation tillage; and OT, respondents that did not use intensive tillage exclusively and did not use conservation tillage exclusively. Some of the OT respondents reported that they use IT in some circumstances and CST for other conditions. Some of the acres in the OT category may have been farmed using CST practices. Respondents in the OT category may adjust tillage to conditions and use IT for a particular crop on a field in one year and CST for the same crop in the same field in a subsequent year.

A cross-tabulation to classify characteristics of respondents by tillage category was used.

Findings

Five hundred and eighty-two (34 percent) of the 1,703 respondents reported that they use IT exclusively (with a primary tillage tool such as a moldboard plow, chisel plow, or offset disk) (Table III-1). Seven percent (117) reported using CST exclusively and the remaining 1,004 (58 percent) reported using OT. The average number of acres planted to annual crops for farms that use IT exclusively is 598. This does not include acres used for perennial crops such as alfalfa and acres used for cropland pasture and rangeland. The average number of acres planted by the exclusive IT farms is significantly less ($P < 0.0001$) than the average number of acres planted by the OT farms (971 acres) which was also significantly less ($P < 0.05$) than the average number of acres planted by the exclusive CST farms (1,220 acres) (Table III-1).

Farms that use IT exclusively farmed 24 percent of the total acres planted to annual crops as reported in the survey. Ten percent of the acres were in the CST exclusive group. This does not mean that only ten percent of the acres were planted with CST practices since CST may have been used on some of the OT acres. However, the finding is reasonably consistent with the CTIC that reported that 10.1 percent of the state’s crop acres were planted CST in 2004 (CTIC 2004) (Table III-1).

Of the respondents that reported using IT exclusively, only seven percent crop more than 1,500 acres. However, the CST exclusive farms are significantly larger and 30 percent crop more than 1,500 acres (Table III-1). This finding is consistent with prior research in that most studies of differences across farms that employ different tillage systems have found that the number of acres planted to annual crops is one of the most significant factors (Rahm and Huffman, 1984; Belknap and Saupe, 1988; Gould, Saupe and Klemme, 1989).

Table III-1. Selected Characteristics of Farms that Use Only Intensive Tillage, Only Conservation tillage, and those farms that use Other Tillage Systems (Other Tillage Includes Farms that use a Combination of Conservation tillage and Intensive Tillage)

	Tillage system used on farm		
Item	**Intensive tillage exclusively**	**Conservation tillage exclusively**	**Other**
Farms	582[a]	117	1,004
Percent of Farms	34%[b]	7%	58%
Average acres planted to annual crops	598[c]	1,220	971
Percent of acres planted to annual crops	24%[d]	10%	66%
Acres planted to annual crops			
Less than 500	69%[e]	35%	49%
500-1000	15%	15%	20%
1001-150(	9%	20%	12%
Over 1500	7%	30%	19%

[a] Five hundred and eighty-two of the respondents reported that they use intensive tillage exclusively.
[b] Thirty-four percent of the respondents reported that they use intensive tillage exclusively.
[c] The average number of acres planted to annual crops for farms that use intensive tillage exclusively is 598. This does not include acres used for perennial crops such as alfalfa and acres used for cropland pasture and rangeland. The average number of acres planted by the exclusive intensive tillage farms is significantly less ($P < 0.0001$) than the average number of acres planted by the other tillage farms which was also significantly less ($P = 0.0476$) than the average number of acres planted by the exclusive conservation tillage farms.
[d] Farms that use intensive tillage exclusively farmed 24 percent of the total acres planted to annual crops.
[e] Of the respondents that reported using intensive tillage exclusively, 69 percent crop less than 500 acres.

Table III-2 includes the average number of acres planted to selected crops by tillage system. Wheat is the primary annual crop grown in the state and it is the predominant crop in each category. Respondents that reported using IT exclusively, plant an average of 555 acres to wheat. Most of these farms plant only wheat. The percentages of acres planted to wheat are 92.5, 66.8, and 79.9 for IT, CST, and OT, respectively. The CST farms have the most diverse cropping systems and the IT farms have the least diverse systems (Table III-2).

Table III-2. Average Number of Acres Planted to Selected Crops by Tillage System

	Tillage system used on farm		
Crop	**Intensive tillage exclusively**	**Conservation tillage exclusively**	**Other**
		Acres	
Wheat	555[a]	815	775
Corn	5	104	45
Cotton	3	52	38
Sorghum	13	106	51
Soybeans	3	117	29
Other crops	21	26	32
Proportion Seeded to Wheat	92.5%	66.8%	79.9%
Proportion Seeded to Crops Other than Wheat	7.5%	33.2%	20.1%

[a] Respondents that reported using intensive tillage exclusively, plant an average of 555 acres to wheat. Most of these farms plant only wheat.

On average, farms that used IT exclusively, rented 297 acres for production of annual crops (Table III-3). The average number of acres rented by the exclusive IT farms (297) is significantly less ($P < 0.0001$) than the average number of acres (550) rented by the OT farms which was also significantly less ($P < 0.05$) than the average number of acres (751) rented by the exclusive CST farms (Table III-3).

Table III-3. Characteristics of Land Rented to Produce Annual Crops by Tillage System

	Tillage system used on farm		
Item	**Intensive tillage exclusively**	**Conservation tillage exclusively**	**Other**
Average acres Rented for Production of Annual Crops	297 [a]	751	550
Zero Land Rented for Production of Annual Crops	40% [b]	26%	27%
Rented (acres)			
Less than 250	50% [c]	25%	37%
250-500	25%	20%	21%
501-750	8%	10%	12%
751-1000	7%	10%	11%
Over 1000	10%	35%	19%

[a] On average, farms that used intensive tillage exclusively, rented 297 acres for production of annual crops. The average number of acres rented by the exclusive intensive tillage farms is significantly less ($P < 0.0001$) than the average number of acres rented by the other tillage farms which was also significantly less ($P = 0.0271$) than the average number of acres rented by the exclusive conservation tillage farms.
[b] Forty percent of farms that used intensive tillage exclusively did not rent any land for production of annual crops. They planted annual crops only on land owned.
[c] Half of the farms that used intensive tillage exclusively and that rented land to produce annual crops, rented less than 250 acres.

Forty percent of farms that used IT exclusively did not rent any land for production of annual crops. They planted annual crops only on land owned. Half of the farms that used IT exclusively and that rented land to produce annual crops rented less than 250 acres. Almost three quarters (74 percent) of the CST farms rented cropland and 35 percent of the 74 percent rented more than 1,000 acres.

Wheat Production System

In the Southern Plains, winter wheat can be grown for either grain-only, forage-only, or for both fall-winter forage plus grain (dual-purpose) (Hossain et al. 2004; Redmon et al. 1995; Redmon et al. 1996; True et al. 2001). Based on the results reported in Table III- 4, seven percent of the acres are planted for forage-only, 68 percent for dual-purpose, and 24 percent for grain only. These results are consistent with those reported by prior studies. Surveys conducted by True et al. (2001) and Hossain et al. (2004) found that between 9-20 percent of the wheat area planted in Oklahoma was intended for forage-only; 49-66 percent was intended for dual-purpose; and 25-31 percent for grain-only.

Of the total wheat acres planted on farms that used IT exclusively, 21 percent was for grain-only and 71 percent is mono-cropped. The 71 percent mono-cropped by the IT exclusive farms is significantly greater than the 52 percent ($p < 0.1$) mono-cropped by the OT farmers and significantly greater ($p < 0.001$) than the 31 per cent mono-cropped by the CST farms (Table III-4).

Table III-4. Wheat Production System and Use of Crop Rotations by Tillage System (% of acres)

		Tillage system used on farm			
		Intensive tillage exclusively	**Conservation tillage exclusively**	**Other**	**Total Percent**
Wheat Production System	Grain Only	21%[a]	37%	24%	24%[c]
	Forage Only	6%	9%	8%	7%
	Dual-purpose	73%	54%	68%	68%
Cropping System	Mono-crop	71%[b]	31%	52%	55%[d]
	Rotated	29%	69%	48%	45%

[a] Of the total wheat acres planted on farms that used intensive tillage exclusively, 21 percent was for grain-only.

[b] Of the total wheat acres planted on farms that used intensive tillage exclusively, 71 percent is mono-cropped. The 71 percent monocropped by the intensive tillage exclusive farms is significantly greater than the 52 percent ($p < 0.1$) monocropped by the other tillage farms and significantly greater ($p < 0.001$) than the 31 per cent monocropped by the exclusive conservation tillage farms.

[c] Twenty-four percent of wheat acres was planted for grain-only.

[d] Fifty-five percent of total wheat acres are not rotated with other crops.

The “rotation” results reported in Table III-4 may seem to be inconsistent with the results reported in Table III-2. For example, in Table III-2 it is reported that only 7.5

percent of the IT exclusive group is planted to crops other than wheat. However, in Table III-4 it is reported that 29 percent of the wheat acres are rotated. The combined information suggests that the crop rotations include several years of wheat. For example, for the CST group a rotation may include two years of wheat followed by one year of an alternative crop.

Table III-5 includes the percentage of farms that use each of the three alternative wheat production systems and the percentage that use crop rotations by tillage group. Table III-5 differs from Table III-4 in that the data in Table III-4 are based on acres rather than farms. Based on the means, the CST farms are more than 2.5 times more likely to use crop rotations than the IT farms.

Table III-5. Wheat Production System and Use of Crop Rotations by Tillage System (% of farms)

		Tillage system used on farm			
		Intensive tillage exclusively	**Conservation tillage exclusively**	**Other**	**Total Percent**
Wheat Production System	Grain Only	24%[a]	38%	23%	23%[c]
	Forage Only	14%	14%	15%	15%
	Dual-purpose	62%	49%	64%	62%
Cropping System	Mono-crop	74%[b]	33%	59%	62%[d]
	Rotated	26%	67%	41%	38%

[a] For those farms that use intensive tillage exclusively and produce wheat, 24 percent plant wheat for grain-only. The dual-purpose category includes those farms that used more than one wheat production system.
[b] For those farms that use intensive tillage exclusively, 74% do not rotate crops.
[c] Twenty-three percent of farms planted wheat for grain only.
[d] Sixty-two percent of farms did not rotate crops.

Tractors, Machines, Implements

Table III-6 includes information regarding tractor and machine use. The survey question used to obtain these responses was intended to determine the types of tractors and machines used on the farms. Thirty-two percent of the respondents reported that they use at least one tractor with more than 225 horsepower. A third of 32 percent, are in the IT group, six percent are in the CST group, and 61 percent are in the OT group. These percentages are very similar to the percentage of farms in each of the three categories: 34 percent IT; 7 percent CST; 58 percent OT. The percentages for all implements used in tillage operations are also similar to the percentages of farms in each of the groups. These finding suggest that the farms that use CST exclusively have retained tillage implements. It is not clear how they "use" tillage tools in their exclusively CST operations.

The findings reported in Table III-6 also show that the chisel plow is the most commonly used primary tillage tool. For example, 77 percent indicated that they use a chisel plow. This compares with 57 percent for an offset disk, 43 percent for a moldboard plow, and 42 percent for a sweep plow. The most frequently used seeding implement is a double disk drill (61 percent) followed by a single disk drill (34 percent), row crop planter (23 percent), air seeder (11 percent), and hoe drill (9 percent).

Table III-6. Percent of farms that reported ownership of tractors of various sizes, and ownership of tillage, planting, and other implements.

Item	Tillage system used on farm: Intensive tillage exclusively	Conservation tillage exclusively	Other	Proportion that Indicated Item Owned [a]
Percent of Farms	34%	7%	58%	
	Tractors Owned			
125 HP or less	34%[b]	6%	60%	70%
126-175 HP	35%	7%	58%	65%
176-225 HP	33%	7%	60%	27%
over 225 HP	33%	6%	61%	32%
	Tillage Implements			
Tandem Disk	33%	6%	61%	52%
Offset Disk	37%	5%	58%	57%
Chisel Plow	36%	5%	59%	77%
Sweep Plow	36%	6%	58%	42%
Moldboard plow	38%	6%	56%	43%
Field Cultivator	36%	5%	59%	59%
Strip-till unit	35%	7%	58%	4%
Vertical till	34%	8%	58%	4%
Other tillage implements	32%	9%	59%	11%
	Planting and Seeding Implements			
Air Seeder	33%	23%	44%	23%
Row Crop Planter	32%	7%	61%	42%
Double Disk Drill	35%	34%	31%	81%
Single Disk Drill	36%	9%	55%	54%
Hoe Drill	36%	6%	58%	19%
	Other Machine Items			
Anhydrous Applicator	36%	5%	59%	26%
Combine	34%	7%	59%	63%
Sprayer	31%	8%	61%	63%
Fertilizer Spreader (dry)	35%	6%	59%	34%
Fertilizer Spreader (wet)	34%	6%	60%	17%

[a] The percentage of farmers surveyed that answered the corresponding item.

[b] Seventy percent of the respondents checked that they owned a tractor with 125 horsepower or less. Of the 70 percent that checked this category, 34 percent were in the intensive tillage group, 6 per cent in the Conservation tillage group and 60 percent in the other tillage group.

Sales and Off-farm Income

Fifty-four percent of the surveyed farms reported less than $100,000 of annual crop and livestock sales (Table III-7). Sixty-five percent of the farms that used IT exclusively had less than $100,000 in annual crop and livestock sales. Fourteen percent of the farms indicated that their farm income was derived exclusively from crop sales. In other words, 86 percent have receipts from sale of livestock. Farms in the CST group were more likely to report crop sales exclusively (23 percent).

On average the farms in the CST group are larger and report more sales. For example, 28 percent of the farms in the CST group reported annual crop and livestock sales in excess of $250,000. Only 12 percent of the IT group reported annual crop and livestock sales in excess of $250,000 (Table III-7).

A positive linear association was found between acres planted and gross farm sales (Table III-7). The coefficients of correlation (ρ) between acres planted and gross farm sales were significantly different from zero ($P<0.0001$) for each group (CT, $\rho = 0.51$; CST, $\rho = 0.55$; OT, $\rho = 0.57$).

The majority of the survey respondents (57%) reported that they have off farm income. However, the source of off farm income was not defined. Since 38 percent (Table III-8) indicated that they are over 65 years of age, it could be that social security is an important source of off farm income. However, this information was not obtained. In the IT group, 21 percent reported earning over 75% of their income from off farm activities (Table III-7).

Table III-7. Characteristics of Respondents by Tillage System

Item	Tillage system used on farm: Intensive tillage exclusively	Conservation tillage exclusively	Other	Total
Crop and livestock sales($,000)				
< 100	65%[a]	39%	49%	54%[b]
100-250	23%	33%	29%	27%
250-500	8%	16%	11%	10%
500-1,000	3%	9%	7%	6%
>1,000	1%	3%	4%	3%
Shares (on-farm gross sales split between crop and livestock)				
Crop exclusively	13%[b]	23%	13%	14%[c]
50%-99 % Crop	52%	55%	52%	52%
>50 % Livestock	35%	22%	35%	34%
Off-farm Income				
Zero	40%[c]	50%	44%	43%[d]
1%-25%	8%	6%	11%	10%
26%-50%	11%	7%	14%	13%
51%-75%	19%	20%	15%	16%
>75%	21%	17%	16%	18%

[a] Sixty-five percent of the farms that used intensive tillage exclusively had less than $100,000 in annual crop and livestock sales.
[b] Fifty-four percent of the farms had less than $100,000 of crop and livestock sales.
[c] Fourteen percent did not have livestock sales.
[d] Forty-three percent reported zero off-farm income.

Seventy percent of the respondents indicated that they were more than 55 years of age (Table III-8). The data show that farmers in the CST group are younger. Only 59 percent of the CST group is more than 55 years of age.

Fifty percent of the respondents reported a high school education level (9 to 12 years of school). Only two percent reported less than nine years (grade school) of education. The remaining 48 percent indicated that they attended college.

About 63 percent of the respondents indicated that they do not have off-farm employment. The highest proportions of producers who do not have an off farm job is under CST. Among the IT group, 17 percent indicated that they work over 40 hours per week off farm. However, only 11 percent of the CST group reported a similar off-farm work load.

A distinct pattern appears in the number of years farmers reported using their current tillage practice. This variable does not necessarily measure the farmer experience; it is an indication of the current farming tillage experience. Seventy-six percent of farmers had been practicing their current tillage for more than four years, 11 percent for less than two years and the rest (13 percent) had between three and four years of experience with current tillage practices (Table III-8). Of the farmers who reported using IT exclusively, 96 percent have used IT for more than four years. In the CST group, 52 percent reported using CST for more than four years, and 48 percent for less than four years. IT farmers have more experience with their tillage method compared to CST farmers.

Table III-8. Characteristics of Respondents by Tillage System

Item	Tillage system used on farm: Intensive tillage exclusively	Conservation tillage exclusively	Other	Total
Age (years)				
18-34	2%[a]	4%	3%	3%
35-54	24%	37%	29%	27%
55-65	32%	31%	32%	32%
>65	42%	28%	37%	38%
Formal Education (years)				
Grade School	2%[b]	5%	2%	2%
High School	55%	44%	48%	50%
Bachelor's	34%	44%	39%	37%
Master's	8%	5%	9%	8%
Doctorate	2%	2%	3%	2%
Off-farm employment				
Zero	60%[c]	70%	65%	63%
1-20 hrs/week	9%	12%	10%	10%
21-40 hrs/week	14%	7%	12%	12%
> 40 hrs/week	17%	11%	13%	14%
Number of years using the current tillage practice				
0-2 years	3%	25% [d]	14%	11%
3-4 years	1%	23%	19%	13%
> 4years	96%	52%	67%	76%

[a] Two percent of the respondents who use intensive tillage exclusively were between 18 and 34 years of age.
[b] Two percent of the respondents who used intensive tillage exclusively attended formal education for less than nine years.
[c] Of those who reported using intensive tillage exclusively, 60 percent did not work off-farm.
[d] Forty-eight percent of those reporting using Conservation tillage exclusively reported that they have using Conservation tillage for four or fewer years.

Table III-9 includes a summary of perceptions. The responses as reported in Table III-9 conform to expectations. The IT group claims less understanding of conservation tillage than the CST group. The CST group is more likely to agree with statements such as CST reduces labor cost, CST reduces fuel costs, CST reduces equipment costs, and CST reduces soil erosion.

One item in “perceived benefits” section is particularly noticeable. Each of the three groups rated “increases yield” lower than any other “perceived benefit” in the group. The growers may well be aware of the research results that consistently show lower wheat grain yield when wheat is grown continuously with conservation tillage practices.

Table III-9 also includes a summary of perceived problems of conservation tillage practices. These responses also conform to expectations. Those in the IT group are more likely to agree with statements that are less favorable for conservation tillage. Furthermore, those in the CST group are more likely to agree with statements that favor conservation tillage.

Table III-9. Perceived knowledge of Conservation tillage, perceived benefits of Conservation tillage, and perceived problems of Conservation tillage

Item	Tillage system used on farm: Convention tillage exclusively	Conservation tillage exclusively	Other	Proportion that Answered [a]
Perceived knowledge of Conservation tillage practices (0-10; 0 = no knowledge; 10 = very knowledgeable)				
	5 [b]	8	7	97%
Perceived benefits of Conservation tillage practices (1-8; 1 = strongly disagree; 8 strongly agree)				
Reduces labor costs	6	8 [c]	7	92%
Reduces fuel costs	7	8	7	94%
Reduces equipment costs	5	7	6	92%
Reduces soil erosion	6	8	7	93%
Increases yield	3	5	4	83%
Generates greater profits	4	6	5	89%
Conserves soil moisture	6	7	6	91%
Reduces soil compaction	5	7	5	90%
Improves ecological diversity	5	7	6	86%
Perceived problems of Conservation tillage practices (1-8; 1 = strongly disagree; 8 strongly agree)				
Lack of state/local research	5	6	5	83%
Increases weed pressure	6	4	6	89%
Soil fertility issues	5	4	5	85%
Increases insect pressure	6	4	6	86%
Residue management	6	4	5	87%
Equipment costs	6	5	6	89%
Increased management skills	5	6	6	86%
Poor economic returns	5	3	5	86%
Difficulty in getting a stand	5	3	5	87%
Inappropriate soil type	5	3	5	84%

Table III-9. Perceived knowledge of Conservation tillage, perceived benefits of Conservation tillage, and perceived problems of Conservation tillage

Item	Tillage system used on farm: Convention tillage exclusively	Conservation tillage exclusively	Other	Proportion that Answered [a]
Grazing concerns	6	4	5	87%
Reduces yields	5	3	5	86%
Uncooperative landlord	4	4	4	77%
Increases soil compaction	5	3	4	85%
Lack of rental equipment	5	4	5	81%
Increases soil and plant disease	6	4	5	85%
Lack of knowledge of Conservation tillage	5	6	5	88%

[a] The percentage of farmers surveyed that answered the corresponding item.
[b] On a scale from zero to ten, the mean reported knowledge of Conservation tillage practices by farmers in the intensive tillage group is five.
[c] Farmers in the Conservation tillage group of respondents strongly agree that Conservation tillage reduces labor cost.

Discussion

The objective of the research was to determine the proportion of Oklahoma farmers that use IT exclusively, the proportion that use CST exclusively, and the proportion that do not use either IT or CST exclusively (other tillage (OT)). An additional objective was to determine characteristics of farms and farmers that fall into each of the three (NT, IT, OT) categories.

A mail survey of Oklahoma farmers randomly selected from the OASS database was conducted. Responses from farmers and ranchers that produce only livestock were removed from the sample as well as responses from those with less than 80 acres of cultivated land. A total of 1,703 usable surveys were evaluated. Of these, 582 (34 percent) reported that they use IT exclusively (with a primary tillage tool such as a moldboard plow, chisel plow, or offset disk), 117 (seven percent) reported using CST exclusively and the remaining 1,004 (58 percent) reported using OT. Farmers that reported using a combination of systems, for example CST on some acres and IT on other acres, were classified in the OT group.

On average, the CST farmers crop more than twice as many acres as the IT farmers (598 versus 1,220 acres of annual crops). Fifty percent of the CST farms plant more than 1,000 acres to annual crops compared to 16 percent of the IT farms. The CST farms have more diversified cropping operations. The IT farms plant more than 90 percent of their annual crop acres to wheat. The CST farms plant only 67 percent of their crop acres to wheat.

The CST farms rent more land for production of annual crops than the IT farms (751 versus 297 acres). Fifty-five percent of the CST farms rent more than 500 acres compared to 25 percent of the IT farms that rent more than 500 acres. Forty percent of the IT farms do not rent any land for production of annual crops.

The use of wheat acres planted differs across the farms. For example, 73 percent of the wheat acres on IT farms are planted for dual-purpose (fall-winter forage plus grain), while only 54 percent of the wheat acres on the CST farms are planted for dual-purpose. The proportion planted for grain-only is 21 percent for the IT farms and 37 percent for the CST farms. The remaining six percent (nine percent) is planted for forage-only on the IT (NT) farms.

The CST farms report that they use crop rotations on 69 percent of their acres. The IT group reported using crop rotations on 29 percent of their acres. Evidently these rotations on IT farms include several years of wheat since the IT group reported that 92.5 percent of their acres are seeded to wheat.

The survey did not detect major differences in the type of machines used on the farms across tillage group. For example, 32 percent of the farms reported that they use at least one tractor with more than 225 horsepower; of this 32 percent, 33 percent were in the IT group (34 percent of the farmers) and six percent were in the CST group (seven percent of the farmers). The survey did not include any questions to attempt to determine differences in hours of use per year for the machines.

Twenty-eight percent of the CST group reported annual crop and livestock sales in excess of $250,000. Only 12 percent of the IT group reported annual crop and livestock sales of $250,000. Twenty-three percent of the CST group reported zero income from livestock compared to only 13 percent of the IT group.

On average the IT farmers are older. Forty-two percent of the IT group are over 65, compared to 28 percent of the CST group. Members of the IT group are more likely to work off the farm. Thirty-one percent of the IT group report that they work more than 20 hours per week off the farm compared to 18 percent of the CST group. This finding is consistent with the findings regarding acres farmed and gross sales. Since the CST group on average farms more acres and has more gross sales from farming activities than the IT group, it is consistent that they would be less likely to work off farm.

Forty-eight percent of the CST group reported that they have been using CST for four years or less. The vast majority (96 percent) of the IT group reported that they have been using IT for more than four years.

Reponses to questions regarding perceived benefits and perceived problems associated with CST were consistent with expectations. Farmers in the CST group are more likely to agree with statements that shed a favorable light on CST and farmers in the IT group are more likely to agree with statements that shed a favorable light on IT. The lowest average perception score among the IT group was assigned to the “increase yield” question. This suggests that members of the IT group, that crop most of their acres to continuous wheat, are concerned about wheat yield response to CST versus IT. This perception is consistent with results of several long term studies that have found lower grain yields with continuous monoculture wheat from CST relative to IT (Daniel et al. 1956; Zingg and Whitfield 1957; Harper 1960; Davidson and Santelmann 1973; Heer and Krenzer 1989; Epplin et al. 1994; Epplin and Al-Sakkaf 1995; Decker et al. 2009).

Another finding of the survey is that farm size matters. This finding is also consistent with prior research that has found that CST is relatively more economical for farms that crop more acres (Epplin et al. 2005; Decker et al. 2009).

The survey confirms that crop rotations are not common in the state. It is likely that the lack of an economically competitive crop to rotate with winter wheat hinders the use of CST in the state. Alternative winter small grain crops such as oats, barley, and rye are not economically competitive. There is no evidence from research plots that summer crops such as corn, soybeans, and grain sorghum will fit well in an economically viable rotation with winter wheat. There is evidence that soybeans do not consistently perform well in the climate, which is characterized by hot, dry, windy summers (Biermacher, Epplin and Keim 2006).

CHAPTER IV

THE CHOICE OF TILLAGE PRACTICE IN OKLAHOMA: HOW FARMERS AND FARMS CHARACTERISTICS AFFECT THE USE OF TILLAGE METHOD?

The objective reported in this part of the thesis is to determine the characteristics of Oklahoma farmers that use IT (intensive tillage) exclusively, CST (conservation tillage) exclusively, RT (reduced tillage) exclusively, and the characteristics of farmers that use $IT_{0.5}$ (50 to 99 percent intensive tillage), $CST_{0.5}$ (50 to 99 percent conservation tillage), $RT_{0.5}$ (50 to 99 percent reduced tillage), and OT (other tillage types). Secondary objectives include determining the relationship between farmers and farms' characteristics and the use of tillage.

Tillage practices depend on many factors. Additional objectives consist of determining how personal/behavioral factors affect the choice of tillage practices; determining how physical factors affect the choice of tillage practices; and determining how financial/economic factors affect the choice of tillage practices.

Information regarding the characteristics of farms in the region that currently use no-till or any form of conservation tillage method relative to those that do not, could be used by extension educators to aid in targeting farmers in order to promote the use of conservation tillage methods.

A contingency table analysis was used to test the independency of explanatory variables with respect to the dependent variable. A multinomial logistic model was also developed to determine how personal/behavioral factors affect the choice of tillage practices; how physical factors affect the choice of tillage practices; and to determine how financial/economic factors affect the choice of tillage practices.

About three quarters of the data (73 percent) included in the model were complete and the other quarter (27 percent) were missing. Three techniques/ models to handle missing values were used and compared in SAS. The model that gives the highest likelihood estimate will be chosen.

Test of Independency: Contingency Table

A contingency table is typically a dichotomous classification of two qualitative variables. Data are not continuous rather they are in categories. The entries for data are called frequencies which can be changed into probabilities or percentages. The sum of entries for a row represents the row marginal totals ($T_{1,}$ $T_{2,}$ and T_3) and for a column, column marginal totals (T_a, T_b, and T_c). The sum of the row marginal totals represents the total (T); the sum of the column marginal totals also represents the total (T) (table IV-1).

Table IV-1. Example one of contingency table

	IT (a)	RT (b)	CST (c)	Row Marginal Totals
Grain Only	T_{1a}	T_{1b}	T_{1c}	T_1
Graze Only	T_{2a}	T_{2b}	T_{2c}	T_2
Dual purpose	T_{3a}	T_{3b}	T_{3c}	T_3
Column Marginal Totals	T_a	T_b	T_c	T

T_{ij}s represent the joint observed values between variables; for instance, T_{3c} represents the number of farmers that seeded wheat for dual purpose using CST.

To check whether or not the factors are independent, the probabilities from the contingency table could be compared. For instance, does the use of tillage depend on the wheat production system (wheat production system and tillage if independent or not?)? If there is a difference in the proportions of grain only, grazing only, and dual purpose across tillage categories, then there is association between the use of tillage and the wheat production system that has the highest proportion.

Table IV-2. Example two of contingency table

	IT (a)	RT (b)	CST (c)	Row Marginal Probabilities
Grain Only (1)	P_{1a}	P_{1b}	P_{1c}	P_1
Graze Only (2)	P_{2a}	P_{2b}	P_{2c}	P_2
Dual purpose (3)	P_{3a}	P_{3b}	P_{3c}	P_3
Column Marginal Probabilities	P_a	P_b	P_c	P

Let's consider the case where the P_{ij}s are probabilities; the law of probability stipulates that two variables are said to be independent (Grain management and Tillage) if their joint probabilities (P_{ij}) is equal to the product of their marginal probabilities (P_i *

P_j). If equation (IV-1) is true ($P_{3c} = P_3 * P_c$), then the use of tillage is independent from the grain management.

$$(IV-1) \qquad F_{ij} = T * P_{ij} \quad \text{since} \quad P_{ij} = P_i * P_j \quad (P_{3c} = P_3 * P_c)$$

Where:

F_{ij} the joint frequencies

T the sum of the row and column marginal total

P_{ij} the joint probabilities

P_i and P_j are the marginal probabilities.

The expected frequency (E_{ij}) can be rewritten in this form:

$$(IV-2) \qquad E_{ij} = T * P_i * P_j \qquad (E_{3c} = T * P_c * P_3)$$

Chi-Square test

Another method to test the independency between variables is a chi-square test. The null hypothesis is that the two variables are independent. The best estimates for the maximum likelihood estimates are given by dividing the marginal total of observed values by the total number of observations:

$$(IV-3) \qquad P_i = \frac{T_i}{T} \quad \text{and} \quad P_j = \frac{T_j}{T}$$

Where T_i and T_j are the marginal totals.

The hypothesis test follows:

$H_{0:}$ $P_{ij} = P_i * P_j$ Independent

H_a: $P_{ij} \neq P_i * P_j$ Not Independent.

Where:

P_i and P_j are marginal probabilities and their maximum likelihood estimate is obtained by dividing the corresponding number of observed frequencies by the total number of frequencies / observations (T_i / T or T_j / T).

The chi square value is calculated as follows:

$$(IV-4) \qquad \chi^2 = \sum_{i=1}^{r}\sum_{j=1}^{c} \frac{(T_{ij}-E_{ij})^2}{E_{ij}}$$

Where r and c symbolize respectively row and column.

The estimated expected frequency is represented by E_{ij}.

$$(IV-5) \qquad E_{ij} = T * P_i * P_j = T * \left(\frac{T_i}{T}\right) * \left(\frac{T_j}{T}\right) = \frac{(T_i * T_j)}{T}$$

The chi square value from the PROC FREQ will be compared to the χ^2 in table and the null hypothesis is rejected if the χ^2 value is greater than the table χ^2.

The initial decision from the independency test is to reject the null hypothesis testing the relationship between the independent variables and the dependent variable (TILLAGE) in all cases except for off farm work where the decision was to fail to reject the null hypothesis and concluded the use of tillage does not depend on the number of hours a farmer works off farm (table III-3).

Based on the likelihood coefficients (-2LogL) which give the highest probability of success, the proportion of acres rented by a farmer for annual crops production (-2LogL =2,673), the number of acres planted to annual crops (-2LogL =2,393), the number of tillage passes (-2LogL =1,714), and the number of acres rented to produce annual crops (-2LogL =1,164) contribute highly in the decision to use a tillage practice by a farmer (table IV-3).

Table IV-4 summarizes the correlation coefficients between the explanatory variables and the different tillage categories where IT exclusively represents farmers that use only IT on their farm, in CST exclusively category farmers plant all their crop acres using CST, and in other tillage group farmers use a mixture of tillage practices on their farms. The closer the coefficient is to plus or minus one, the stronger the correlation between the variable and the use of tillage. For instance as farmers age increases, the likelihood to use IT exclusively increases (p-value=0.0001), while the likelihood to use CST exclusively decreases (p-value=0.0164), but no statistical significance in the use of other type of tillage methods (p-value=0.1423). Under IT exclusively the variables that have the highest correlation coefficients (positive or negative) in absolute values with significant probability values less or equal to one percent are YEARS_TILLING (correlation = +33 percent), BENEFITS (correlation = -28.8 percent), CROPPING_SYSTEM (YES) (correlation = -17.2 percent), RENT (correlation = -16 percent), and SALES (correlation = -15.7 percent). The variables that have the highest correlation coefficients (positive or negative) in absolute values with significant probability values less or equal to one percent under CST exclusively are PASSES (correlation = -46.1 percent), BENEFITS (correlation = +19.1 percent), PROBLEMS (correlation = -17.1 percent), and CROPPING_SYSTEM (YES) (correlation = +16.5 percent). For other tillage category variables that have the most important and significant correlation coefficients are BENEFITS (correlation = +17.9 percent), PASSES (correlation = +26.6 percent), and YEARS_ TILLING (correlation = -25.6 percent).

Most of the signs associated with the correlation coefficients were consistent with expectations. A negative sign on the coefficient of EDUCATION under CST exclusively was not expected but this coefficient was insignificantly different from zero. The signs on the SHARES in on-farm income between crop sales and livestock sales under IT exclusively and CST exclusively were not expected. The implications are more crops increases the likelihood that a farmer will use CST exclusively (p-value=0.0003),

Table IV-3. Relationship between explanatory variables and the use of Tillage

VARIABLES	p-value	Likelihood	Relationship
AGE	<.0001	97.9	Not Independent
KNOWLEDGE	<.0001	331.6	Not Independent
BENEFITS	<.0001	301.6	Not Independent
PROBLEMS	<.0001	140.1	Not Independent
IMPACT	<.0001	37.4	Not Independent
PASSES	<.0001	1,714.1	Not Independent
ACRES_FARMED	<.0001	2,393.4	Not Independent
WHEAT_PRODUCTION	0.0023	38.6	Not Independent
CROPPING_SYSTEM	<.0001	123.9	Not Independent
RENT	0.0131	1,164.8	Not Independent
PROP_RENTED	<.0001	2,673.1	Not Independent
SALES	<.0001	152.0	Not Independent
SHARE	0.0023	298.8	Not Independent
OFF_FARM_INCOME	0.0544	49.2	Not Independent
OFF_FARM_WORK	0.6276	28.4	Independent
EDUCATION	0.0094	43.6	Not Independent
YEARS_TILLING	<.0001	376.4	Not Independent

decreases the likelihood that a farmer will use IT exclusively (p-value=0.3), decreases the likelihood that a farmer will use other tillage type (p-value=0.4).

Table IV-4. Correlation coefficients

	IT exclusively [a]		CST exclusively [b]		Other tillage [c]	
VARIABLES	p-value	Correlation	p-value	Correlation	p-value	Correlation
AGE	0.005	6.9%	0.0164	-5.9%	0.1423	-3.6%
KNOWLEDGE	0.0339	-5.2%	0.556	1.5%	0.0826	4.3%
BENEFITS	<.0001	-28.8%	<.0001	19.1%	<.0001	17.9%
PROBLEMS	<.0001	12.6%	<.0001	-17.1%	0.1691	-3.3%
IMPACT (YES)	0.6952	1.0%	0.0096	-6.3%	0.3411	2.3%
PASSES	0.1055	-4.0%	<.0001	-46.1%	<.0001	26.6%
ACRES_FARMED	<.0001	-13.5%	0.0049	6.8%	<.0001	9.5%
WHEAT_PRODUCTION						
GRAIN ONLY	0.808	0.6%	0.0001	9.3%	0.0276	-5.3%
FORAGE ONLY	0.9472	-0.2%	0.3271	-2.4%	0.5702	1.4%
DUAL PURPOSE	0.964	0.1%	0.0019	-7.5%	0.1214	3.8%
CROPPING_SYSTEM (YES)	<.0001	-17.2%	<.0001	16.5%	0.0008	8.1%
RENT	<.0001	-16.0%	0.0002	9.3%	<.0001	10.7%
PROP_RENTED	0.1834	3.3%	0.8279	-0.5%	0.2406	-2.9%
SALES	<.0001	-15.7%	0.0146	6.2%	<.0001	11.9%
SHARE	0.3022	-2.6%	0.0003	8.9%	0.404	-2.1%
OFF_FARM_INCOME	0.132	3.7%	0.5934	-1.3%	0.2389	-2.9%
OFF_FARM_WORK	0.0515	-4.8%	0.5762	-1.4%	0.0305	5.3%
EDUCATION	<.0001	33.0%	<.0001	-12.5%	<.0001	-25.6%

[a] Intensive tillage exclusively : producers that reported they farmed their entire crop acres planted to annual using IT method.

[b] Conservation tillage exclusively: producers that reported they farmed their entire crop acres planted to annual using conservation tillage method.

[c] Producers in this category did not use either intensive tillage exclusively or conservation tillage exclusively

Choice of the Model that Gives the Greatest Likelihood Ratio

A third of the survey data that were usable was incomplete. When ran in SAS software, incomplete information was automatically deleted/excluded from the analysis. A producer surveyed might answer to all questions but one; excluding the response from the analysis due to one missing datum would result in the loss of all information contained on the questionnaire.

Three models using the same variables are developed and compared; the model with the greatest likelihood ratio (-2LogL) will be chosen for further analysis (inference; marginal effect; by region analysis). Two SAS procedures (LOGISTIC and GLIMMIX) were utilized for each model. The procedure with the best statistical likelihood parameter estimates will be used.

Model one: Missing values case-deletion

Of the 1,703 usable observations, about 32 percent were not fully complete. If those with missing values had been deleted, only 1,246 observations would have been available for evaluation. The consideration of only survey forms with complete information without considering the missing data could result in unrepresentative and incorrect conclusion (Rubin 1987). According to Schafer (1987) when missing values represent a small proportion of the entire data (about five percent), then case deletion is a more preferred method; alternatively for a substantial proportion of missing data in a dataset, case deletion might not be efficient. In this first model, variables were included as they were typed in EXCEL. Only one variable, the number of acres planted to annual crops reported by producers (ACRES_FARMED), was transformed into a categorical variable (in all three models) because the multinomial logistic procedure fits best for categorical variables.

Model two: Weighted average: Incomplete data replacement by corresponding complete data average

In the second model, missing values for a variable were replaced by its corresponding complete data average which keeps the observed means unchanged; however, this technique affects the structure of the variance-covariance matrix which will bias the estimated variances and co-variances toward zero (Schafer, 1997). In this model, missing values for a specific variable were replaced by the average computed using the observed values of the corresponding variable.

Model three: Multiple Imputation using Markov Chain Monte Carlo

The last technique performs multiple imputations (MI) on missing data to generate pseudorandom draws using Markov chains as proposed by Schafer in 1997. In the MI technique introduced by Rubin (1987) to handle missing values, each nonresponse point is replaced by m simulated values (for $m>1$). The missingness pattern of the data determines whether or not MCMC method should be used.

<u>Assumptions</u>

The reference used to derive the assumptions of the MCMC is from Schafer (1997). Let's denote by Y a (r, c) rectangular dataset, where r represents the rows and also each of the producers surveyed, c represents the columns and also the different explanatory variables. Let's consider the situation where the rectangular (r, c) matrix is not fully observed and yi , the ith producer for i= 1, 2, …, n. The first assumption is that the rows are distributed independently and identically as in Schafer (1987), thus the probability density function (pdf) of the complete data (observed and missing) is given by:

$$(\boldsymbol{IV-6}) \qquad \boldsymbol{P(Y|\theta) = \prod_{i=1}^{r} f(y_i|\theta)}$$

where f is a row pdf, θ a vector of unknown parameters.

The second assumption concerns the missing data patterns. Let's denote by Y_{obs} the observed part of Y, and by Y_{mis} the missing part of Y, and R a (r, c) matrix whose elements are zero for missing values or one for observed values (Rubin, 1976). The second assumption referred to as missing at random (MAR) is the probability that a missing value is a function of Y_{obs} but not of Y_{mis}.

$$(\boldsymbol{IV-7}) \qquad \boldsymbol{P(R|Y_{obs}, Y_{mis}, \xi) = P(R|Y_{obs}, \xi)}$$

An ordered dataset of Y_1, Y_2, Y_3, …, Y_P has a monotone missing data patterns when for a particular individual if a variable Y_j is missing implies that all following variables Y_k are missing, for j<k (SAS documentation chapter 9). For arbitrary or non-monotone missing data patterns, a MCMC is used to impute data assuming multivariate normality (Schaffer 1997). However, the drawback of this technique is that the imputed data are not observed and the observed correlations might be inflated; this biases the correlations away from zero (Schaffer 1997).

The GLIMMIX procedure gives larger likelihood ratio coefficients in all three models compared to the LOGISTIC procedure but only slightly. Four variables were not significant in each of the models (type III tests of fixed effects). Model 1 has the smallest likelihood coefficient (-2LogL=3077) and used only 1246 observations; model 2 used all observations (no missing data), and has the largest likelihood coefficient (-2LogL=4346); model 3 used also all the observations in the data (1,703), and has the second largest likelihood coefficient (-2LogL=4333) (table IV-5). From this approach, model 2 is more preferable to this particular data. Even though the MCMC was found to be a good method for handling missing variables by Schafer (1997), replacing missing values by their average was found to be a better technique.

However, the coefficient of determination of model 1 is the highest (R^2=71 percent) and model 2 has the smallest coefficient of determination (R^2=62.5 percent) (table IV-5).

Table IV-5. Choice of model based on likelihood ratio coefficient (-2LogL)

	Model 1		Model 2		Model 3	
Procedure	-2LogL	R^2	-2LogL	R^2	-2LogL	R^2
Observation used	1,246		1,703		1,703	
LOGISTIC	2948.144	0.7090	4344.497	0.6247	4332.807	0.6272
GLIMMIX	3077.35		4346.09		4333.03	

Additionally, a goodness of fit test is conducted to ensure that the fitted model is a good fit of the data. Since the difference in likelihood coefficients between the GLIMMIX and LOGISTIC procedures is very small and the manipulation of the later procedure is easier, the LOGISTIC procedure was used in all subsequent analyses. The goodness of fit addresses the question “Is the model a good fit?” Using the SAS option LACKFIT AGGREAGTE SCALE=NONE, a good fit occurs when the p-value is insignificant; as the p-value gets close to one, the conclusion is that the model is a very good fit of the data.

The goodness of fit hypothesis test follows:

$H_{0:}$ Model is a good fit of the data

H_a: Model is not a good fit of the data.

Results are reported in table IV-6. The initial decisions are to fail to reject the null hypothesis and conclude that the three models are very good fits of the data.

Table IV-6. Pearson Goodness of Fit Statistics

	Model1	Model2	Model3
Pr > ChiSq	0.8042	0.8376	0.8415

The weighted average model (model 2) is chosen in the rest of the analysis.

Conceptual Framework and Expectations

The choice of a tillage practice (TILLAGE) is modeled as a function of the independent/explanatory variables (behavioral, physical and financial). The conceptual equation is in this form:

Choice of Tillage Practice = f (Farm physical characteristics, Farming management systems, Producer behavioral characteristics, Farmers' perception on conservation tillage).

Farm Physical Characteristics

Most studies on conservation tillage adoption found the number of acres planted to annual crops to be one of the most significant factors that diverges IT to CST (Rahm and Huffman 1984; Belknap and Saupe 1988; Gould, Saupe and Klemme 1989). The number of acres farmed ACRES_FARMED is expected to have a positive coefficient, thus a positive relationship on the use of CST.

Rented land adds to the acres for annual crop production; thus, as a greater proportion of the acres for annual crop production is rented, it is more probable to expect the producer to use CST. For greater proportion of rented land PROP_RENTED, the probability of using CST is higher. A positive relationship between the proportion of rented land and the choice to use CST is more likely.

Farming Management Systems

Wheat can be grown using several production systems: grain only purpose, forage only purpose, and dual purpose. Dual purpose is the most common wheat production system in Oklahoma. The variables GRAIN_WHEAT, FORAGE_WHEAT, and DUAL_WHEAT are dummy variables that take the value of one respectively for grain only purpose (GO), forage only purpose (FO), and dual purpose (DP). A positive relationship between forage only and dual purpose with the use of CST is predicted. However, a negative relationship between grain only purpose and the use of CST is expected.

The vast majority of Oklahoma crop acres are planted to winter wheat. Winter wheat is usually not rotated with other crops. Historically conservation tillage is less economical than intensive tillage for continuous monoculture winter wheat production for small farms. Intensive tillage farmers are expected to allocate a greater proportion of their crop acres to monoculture wheat than CST farmers. A negative relationship is therefore more probable between monoculture wheat and the use of CST.

Producer Behavioral/Personal Characteristics

The expected sign between producers' age and the use of tillage is difficult to predict. It is more likely to have a negative sign on the use of CST because older farmers are usually more adept to the same IT practice they are using. Additionally, the return on investments required in machinery for a successful CST requires a long planning horizon. The older the farmer the more reticent he may be to adopt and to use CST. A negative relationship between farmer age and the use of CST is predicted.

The education level being a source of information on the effects of erosion, a positive correlation is expected between the adoption of CST and the producer education level.

Conservation tillage methods, especially no-till, require less labor than intensive tillage; farmers could therefore get an extra activity not necessarily related to farming. The number of hours worked off-farm (EMPLOYMENT) is hypothesized to be positively related to the use of CST methods (table IV-3).

Farmers' Perception on conservation tillage

The understanding of CST practices (KNOWLEDGE) was found to be significantly related to the use of tillage practices. The more knowledgeable a farmer is of CST practices, the more likely he is to use CST. All coefficients were negative except OT coefficient that was positive. There was a significant distinction between IT and CST, and between OT and CST. Moreover, compared to CST, IT producers reported a lower rate of perception of CST practices but OT farmers reported greater scores on the perception of CST practices than CST producers (table IV-8).

The perceived reduction in soil erosion of CST (EROSION_REDUC), the perception that CST practices generate greater profits (PROFITS_GREATER, the perception that CST practices conserve soil moisture (MOISTURE_SOIL), and the perception that CST practices reduce soil compaction (COMPACTION) are expected to favor the use of CST practices. Producers that perceive these benefits are more likely to use CST.

The perception that CST practices increase weed and insect pressure (PEST_PRESS), the perceived increase in plant and soil disease (DISEASES), the negative impact of livestock on CST small grain acres (IMPACT) are expected to be negatively associated with the use of CST practices. Producers that perceive these problems are less likely to use CST.

Empirical Model

The multinomial logistic model is often used when the dependent variable is a categorical variable and the explanatory variables are individual characteristics. The explained variable is a seven level unordered nominal category that represents the tillage practices a farmer uses on farm. A generalized logistic model was fitted to determine the relationship between producers' characteristics and the use of tillage in Oklahoma. Producers were classified as pure users when they reported using only one type of tillage practice; they are partial users if they are doing more than one tillage method on their farm.

The pure tillage categories are:

intensive tillage exclusively (IT): producers that reported they farmed their entire crop acres planted to annuals using IT;

reduced tillage exclusively (RT): producers that reported they farmed their entire crop acres planted to annuals using RT;

and conservation tillage exclusively (CST): producers that reported they farmed their entire crop acres planted to annuals using CSTP.

Producers that reported use of multiple systems were separated into four categories:

intensive tillage ($IT_{0.5}$): in this category, producers reported they farmed between 51% and 99% of their crop acres planted to annuals using IT, and the other proportion using RT and/or CST;

reduced tillage ($RT_{0.5}$): in this category, producers reported they farmed between 51% and 99% of their crop acres planted to annuals using RT, and the other proportion using IT and/or CST;

conservation tillage ($CST_{0.5}$): in this category, producers reported they farmed between 51% and 99% of their crop acres planted to annuals using CST, and the other proportion using IT and/or RT;

and other tillage (OT): this category includes producers that used a combination of the three tillage methods with no single method (IT, RT, CST) used on more than 50% of their total crop acres.

The basic assumption is that a rational producer will use a tillage sytem that provides the highest utility; producers' utility is not observable but the choice they made is. Therefore, the i^{th} producer's utility function will be a function of the specific producer characteristics which represents the non-stochastic utility component and a stochastic component which captures the unobserved producer characteristics (equation IV-8). The model follows the assumption of McFadden (McFadden 1970).

Assuming a linear specification of the utility function:

(IV-8) $$U_{ij} = V_{ij} + \varepsilon_{ij}, \text{ where } V_{ij} = \beta_j X_{ij}$$

i: subscript for producer j: alternative tillage practice

The probability that the i[th] farmer will choose to use a tillage practice say IT when the utility from using IT is the highest among all tillage methods (equation IV-9).

$$(IV-9) \qquad P(IT) = P(U_{IT} > U_{CST}, U_{IT} > U_{RT}, U_{IT} > U_{IT_{0.5}}, U_{IT} > U_{CST_{0.5}}, U_{IT} > U_{RT_{0.5}}, U_{IT} > U_{OT}$$

Generalization of equation (IV-10):

(IV-10) $$P\left(Tillage_j\right) = P\left(U_{ij} > U_{ik}\ for\ all\ j \neq k\right)$$

Assuming the error terms (stochastic component) are independently and identically distributed, a multinomial logistic model could be used to fit the regression. Let CST be the baseline or reference category with parameter estimates normalized to zero; this requires the estimation of six equations, one for each tillage category relative to the CST group. The baseline or reference category has the same role that as in the dummy-coding of a nominal variable. Consider a producer who chooses among the seven different alternative tillage practices; let P_{ij} denote the probability a farmer i chooses an alternative tillage practice j, and $\sum_{j=1}^{j=7} P_{ij}=1$. The probability of choosing an alternative tillage is given in equation (IV-11):

(IV-11) $$P_{ij} = \frac{exp(\beta_j X_i)}{\sum_{k=1}^{m=7} exp(\beta_k X_i)}$$

$ß_j$: parameter estimate specific to a tillage practice j.

β_k: parameter estimates of the seven tillage practices.

X_i: the i^{th} producer ‘characteristics which are constant across alternative tillage methods.

The denominator represents the exponential sum of all tillage practices and is identical for each tillage group probability calculation, while the numerator represents a specific exponential form of a tillage method. For instance the probability of using IT is equal to the exponent of IT parameters times their characteristics evaluated at the mean values divided by the sum of the exponent of all tillage category parameter estimates multiplied by their corresponding characteristics evaluated at the mean values.

An alternative to the logistic model would be the probit model. The logistic model is easier to compute, the exponent of the logistic coefficients can be interpreted as odds ratios. However, the independence from irrelevant alternatives (IIA) property is a problematic aspect of the multinomial logistic model. It assumes that the ratio of the probabilities between any two tillage methods is the same despite of what other alternative tillage practices are in the choice set or what the characteristics of the other alternatives are. In other words, the probability of choosing IT relative to CST does not depend (independent) on other alternatives which are irrelevant to the choice between IT and CST. This restriction can also be seen as the equality between cross elasticities due to a change in probabilities of producers’ characteristics for all alternatives when a given alternative j varies. The IIA property makes the analysis easier. In the following formula (equation IV-12) the choice probabilities between option j and option l does not depend on any other options other than options j and l.

$$\text{(IV-12)} \qquad \frac{P_{ij}}{P_{il}} = \frac{\left[exp\left(\beta_j X_i\right)\right] / \left[\sum_{k=1}^{m=7} exp(\beta_k X_i)\right]}{\left[exp(\beta_l X_i)\right] / \left[\sum_{k=1}^{m=7} exp(\beta_k X_i)\right]} = \frac{exp\left(\beta_j X_i\right)}{exp(\beta_l X_i)} = exp\ \left[X_i\left(\beta_j - \beta_l\right)\right]$$

The interpretation of the β coefficients is difficult but the sign associated with each parameter estimate can be useful. Thus, the marginal effects of each factor are often used. The marginal effect is given by:

(IV-13) $$\frac{\partial P_{ij}}{\partial X_i} = P_{ij}\left(\beta_j - \sum_{k=1}^{m=7} \beta_k P_{ik}\right)$$

Results

The relationship between the dependent variable (TILLAGE) and each independent variable is based on the overall statistical significance of the variable in the model. The probability value (p-value) of each independent variable is given by a letter (a, b, or c) above the variable. Following the same approach, the variables AGE, ACRES_FARMED, KNOWLEDGE, CROPPING_SYSTEM, IMPACT, GRAIN_WHEAT, FORAGE_WHEAT, DUAL_WHEAT, EROSION_REDUC, PROFITS_GREATER, COMPACTION, PEST_PRESS, DISEASES, and all the regions except the South Central are significantly related to the dependent variable TILLAGE with probability values less than or equal to the level of significance of one percent (Type III fixed effect) (table IV-8). However, MOISTURE_SOIL, EDUCATION, EMPLOYMENT, and PROP_RENTED, were not statistically significant in the model (Type III fixed effect) (table IV-8).

After finding variables that are significantly related to the dependent variable, the next step is to look at the sign and the individual significance of the parameter estimates. In some cases, the variable might not be related to the dependent variable but is helpful in differentiating one of the tillage categories from the reference category CST. For instance, the independent variable ACRES_FARMED explains the overall use of tillage practice and is significant in differentiating between the choice to use CST and IT categories (table IV-8).

Farm Physical Characteristics

The number of acres farmed (ACRES_FARMED) was strongly related to the dependent variable (TILLAGE). A negative sign on the coefficients associated with the explanatory variable ACRES_FARMED was predicted. The results suggest that the number of acres planted to annual crops is significantly explaining the difference between IT and CST categories (table IV-8).

There was a not a significant relationship between the use of tillage and the independent variable PROP_RENTED. All coefficients on the variable PROP_RENTED were also insignificant (table IV-8).

Farming Management Systems

The variables GRAIN_WHEAT, FORAGE_WHEAT, and DUAL_WHEAT were statistically significant at the one percent level. All the parameter estimates associated with these variables were positive and only one was not statistically significant. This implies that CST producers are less likely to practice any of these wheat production practices compared to other tillage groups.

The CROPPING_SYSTEM variable is a dummy variable whether or not the producer has some of his crop acres in rotation and takes the value of one for crop rotation and zero for monocrop system. The CROPPING_SYSTEM variable was significant at the one percent level with expected negative sign associated with all coefficients. The negative signs suggest that producers that answered yes they rotate their crop acres are more likely to use CST practices. In other words, CST farmers use monoculture systems less likely than other farmers. Only the coefficient on OT group was not significantly different from zero (table IV-8).

Producer Behavioral/Personal Characteristics

There was a significant association between the variable AGE and the use of tillage practice (dependent variable). There were statistical differences found between IT and CST, between RT and CST, between $IT_{0.5}$ and CST, and between OT and CST. This variable was hypothesized to be negatively related to the use of CST; positive signs on the significant coefficient under IT, RT, and $IT_{0.5}$ imply that CST farmers are younger producers but the negative on the significant coefficient under OT suggest that CST are older than OT producers (table IV-8).

The variable EDUCATION was not significant in the model but distinguishes CST method to OT tillage category. Some studies found a significant negative relationship to the use of CST (Gould, Saupe, and Klemme 1989; Rahm and Huffman 1984) and others found a significant positive relationship to the use of CST (Ervin and Ervin 1982; Wu and Badcock 1997). Other studies conducted by D’Emden, Llewellyn, and Burton in 2007, and Belknap and Saupe in 1988 found EDUCATION to be insignificant factor in explaining the use of tillage. There is evidence that OT farmers are more educated than CST producers.

The variable EMPLOYMENT was not significantly related to the dependent variable. However, a weak significant difference was found on the coefficient of IT and

$RT_{0.5}$ relative to CST. Producers that reported using IT and $RT_{0.5}$ method are more likely to work off-farm compared to CST producers (table IV-8). Gould, Saupe, and Klemme (1989) used the proportion of off farm employment; they found a significant positive relationship with the use of CST.

Farmers' Perception on conservation tillage

The effect of KNOWLEDGE on TILLAGE was significant. There was empirical evidence that the perceived knowledge of conservation tillage practice has a positive effect on the use of CST compared to IT but negative and insignificant effect compared to OT category. The significant negative signs on the parameter estimates imply that farmers with greater knowledge on CST practices are more likely to use CST than farmers with less knowledge on CST which requires more management.

The perceived reduction in soil erosion of CST (EROSION_REDUC) was significantly associated with the dependent variable (TILLAGE). All the coefficients were found to be negative. However, the coefficient on OT group was not significant. The negative significant signs of the coefficients imply that CST producers rated greater scores on the perceived reduction in soil erosion from using CST techniques compared to other producers (table IV-8).

The perception that CST practices generate greater profits (PROFITS_GREATER) was significantly associated with the dependent variable (TILLAGE). All the coefficients that were significant were found to be negative. The coefficient associated with the OT category was positive but insignificantly different from zero. The coefficient on OT group was not significant. The negative significant signs of the coefficients imply that CST producers rated greater scores that CST practices generate greater profits (table IV-8).

The perception that CST practices conserve soil moisture (MOISTURE_SOIL) was not significantly associated with the dependent variable (TILLAGE). However, two of the coefficients were found to be significant. All the parameter estimates on this variable were negative. The negative significant signs of these estimates imply that CST producers rated greater scores that CST practices conserve soil moisture (table IV-8).

The variable COMPACTION, perception that CST practices reduce soil compaction, was significantly related to the dependent variable (TILLAGE). All the coefficients were found to be negative and significant. The negative significant signs of these estimates imply that CST producers rated greater scores that CST practices reduce soil compaction (table IV-8).

The variable PEST_PRESS, perception that CST practices increase weed and insect pressure, was significantly related to the dependent variable (TILLAGE). All the coefficients were found to be positive and significant except the OT parameter estimate that is not significant. The positive significant signs of these estimates imply that CST producers rated smaller scores that CST practices increase weed and insect pressure (table IV-8).

The perceived increase in plant and soil disease denoted by the variable DISEASES was significantly related to the dependent variable (TILLAGE). All the coefficients were found to be positive. Three of the estimates were significantly different from zero. The positive significant signs of these estimates imply that CST producers rated smaller scores that CST practices increase plant and soil disease (table IV-8).

The negative impact of livestock on CST small grain acres (IMPACT) was significant in the model. Four of the estimates were significant and positive. This implies that CST producers are less likely to report that livestock negatively impacts the use of CST methods on small grain acres (table IV-8).

Discussion

Farm Physical Characteristics

The sign of coefficients associated with ACRES_FARMED under IT and RT were negative and significant. There was statistical evidence that CST farmers planted more acres to annual crops than IT and RT farmers. The results are consistent with prior studies (Rahm and Huffman 1984; Belknap and Saupe 1988; Gould, Saupe and Klemme 1989; Erenstein and Cadena 1997). The marginal effects by increasing by one acre the average number of acres planted to annual crops did not show any difference in the choice that a producer will make.

Farming Management Systems

The strong positive statistical significances of the coefficients associated with the variables GRAIN_WHEAT, FORAGE_WHEAT, and DUAL_WHEAT show that CST producers reported less proportion of their wheat for grain only, forage only, and dual purposes compared to the remaining tillage categories. Producers that use IT and RT methods are more likely to seed their wheat grains for grain only purpose, forage only purpose and dual purpose compared to CST producers.

According to the MNL model, CST producers are more likely to rotate their crops and less likely to use monocrop system. This suggests that the use of crop rotation (CROPPING_SYSTEM) is positively related to the use of CST. Farmers that use crop rotations are more likely to use CST techniques than farmers that do not rotate. This relationship is expected since with monocropping system, weed, insect and disease problems are more difficult to manage with CST. Crop rotations may be used to break cycles of weed, disease, and insect pressure and increase the likelihood of successful CST. The marginal effects of the CROPPING_SYSTEM variable for a farmer to switch from monocrop system to rotation system show that there is 0.25 percent chance the farmer will not choose IT methods, 0.004 percent chance the producer will choose RT techniques, 0.214 percent chance he will choose $IT_{0.5}$, 0.019 percent chance he will choose RT, 0.011 percent chance he will choose CST, and 0.003 percent chance he will choose OT methods.

Producer Behavioral/Personal Characteristics

The positive signs on the variable AGE suggest that there is significant evidence that CST producers are younger than IT producers, RT producers, and $IT_{0.5}$ producers. Similar results were found by Gould, Saupe and Klemme (1989). By increasing farmers' age by one year, there is 0.01 percent chance that the farmer will not use IT techniques and 0.014 percent chance that he will use RT methods.

Farmers' Perception on conservation tillage

The significant negative signs on the parameter estimates associated with EROSION_REDUC, PROFITS_GREATER, MOISTURE_SOIL, and COMPACTION suggest that higher benefits ratings from using CST methods are more likely to be reported by CST producers. Ervin and Ervin in 1982 found producers that perceive erosion as a problem are more likely to adopt CST techniques. Alternatively, the significant positive signs on the parameter estimates associated with PEST_PRESS, and DISEASES imply that CST producers less likely rated these variables. Producers that use CST are more likely to perceive that CST methods reduce soil erosion, generate greater profits, reduce soil compaction, and conserve soil moisture. However, CST producers are more likely to perceive that CST practices increase weed and insect pressure, and increase plant and soil diseases.

Producers that use CST practices are less likely to perceive that livestock negatively impacts the use of CST methods on small grain acres.

Implications

The crop rotation system is an important factor in encouraging producers to adopt and to continue using CST methods. In Oklahoma, summer crops such as corn, soybeans, and grain sorghum that can fit well in an economically viable rotation with winter wheat are problematic. The promotion of CST techniques through the use of rotation systems should follow the development of environmentally and economically adapted/suitable crop that could fit into rotation with winter wheat in a climate characterized by hot, dry, windy summers. The introduction of an economically viable crop rotation to IT producers will allow them to adopt CST practices. There is ten percent chance that with the introduction of a viable rotation crop to IT farmers that they will switch to another tillage system. Three percent chance they will not adopt RT, three percent chance they will adopt $CT_{0.5}$, four percent chance they will adopt $RT_{0.5}$, two percent chance they will adopt $CST_{0.5}$, two percent chance they will adopt OT, and two percent chance they will adopt CST. The availability of a rotation crop will encourage IT producers to switch to another tillage systems with seven percent chance the farmers will adopt conservation tillage techniques (figure IV-1).

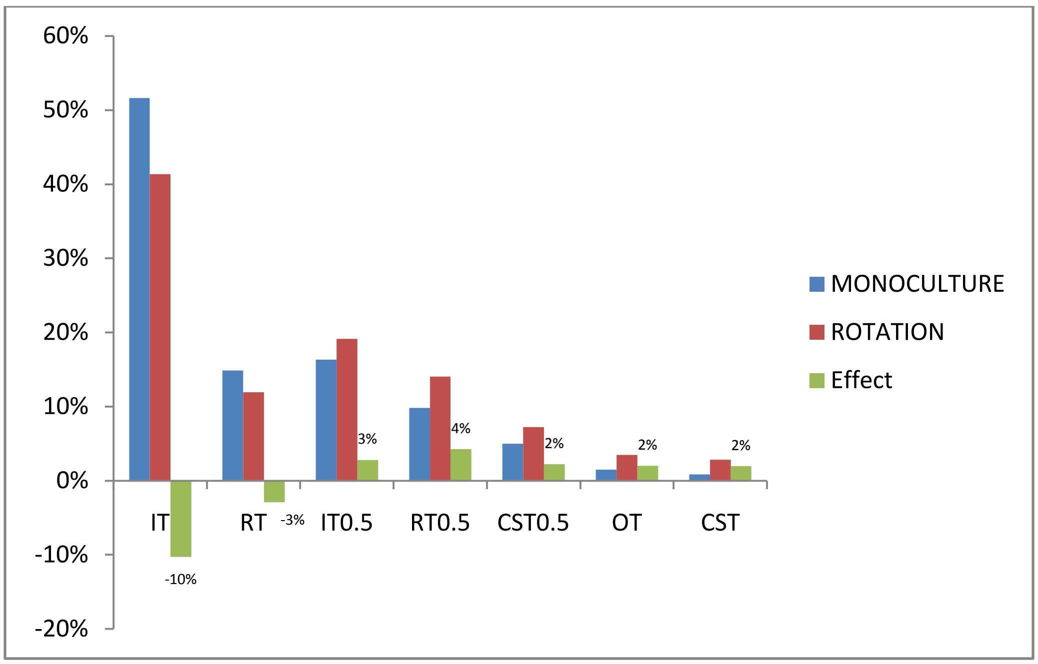


Figure IV-1. Probability of a tillage group farmers of using rotation and monocrop systems and the marginal effects

By increasing the average number of acres that IT producers are planting to annual crops by 100acres, the results suggest there is 0.626 percent chance the producer will switch from IT to other tillage production systems, 0.077 percent chance the farmer will not use RT practice, 0.277 percent chance the farmer will adopt $IT_{0.5}$, 0.25 percent the farmer will adopt $RT_{0.5}$, 0.12 percent the producer will adopt $CST_{0.5}$, 0.041 percent the producer will adopt OT, and 0.017 percent the producer will adopt CST.

The implications in figure IV-2 suggest that by increasing the knowledge of IT farmers on CST practices, the proportion of IT farmers will decrease and the proportion of farmers using CST practices increases (figure IV-2).

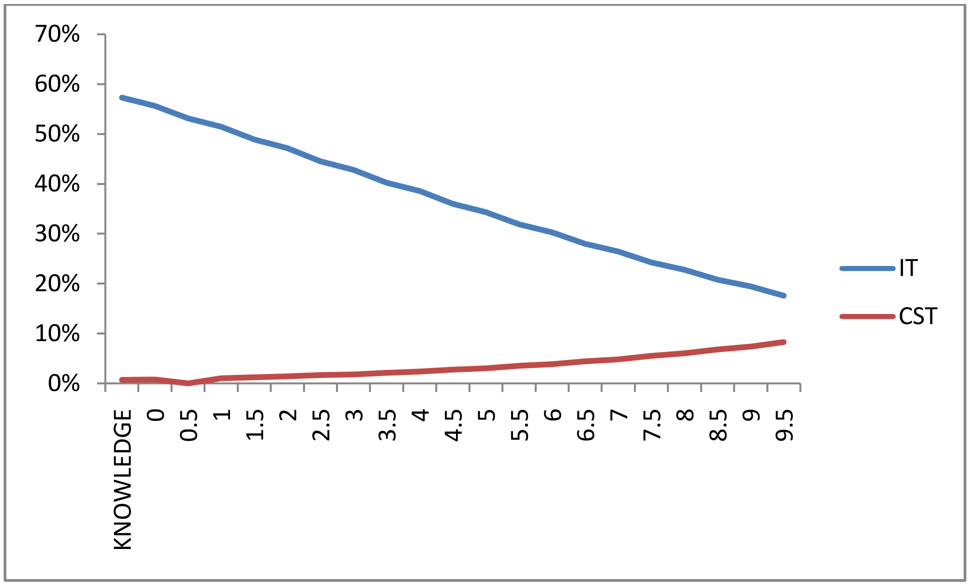


Figure IV-2. Probability of using IT and CST methods by increasing the understanding of CST practices.

The IT producers perceived CST methods increase pest pressure; thus IT farmers rated more likely greater scores than CST producers. The highest score is eight, strongly agree that CST methods increase pest pressure and zero, strongly disagree that CST methods increase pest pressure. Producers that do not perceive CST techniques as a source of pest pressure are more likely to use CST. In figure IV-4, as the rating score increases the probability of using IT increases but the probability of using CST decreases. An implication to increase the likelihood of CST methods in Oklahoma would be to develop a least cost effective means to control pest pressure.

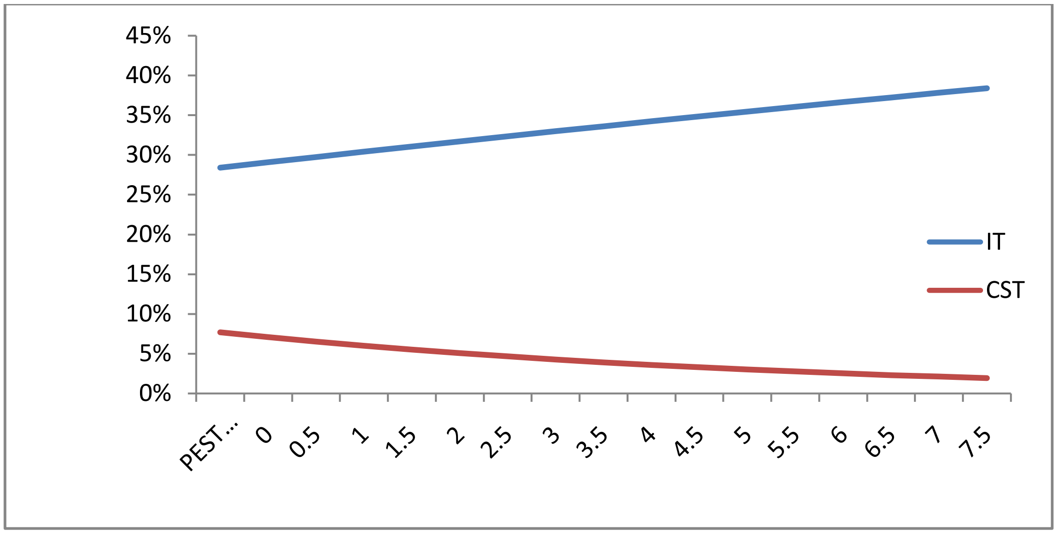


Figure IV-3. Probability of using IT and CST methods by increasing the perception of pest pressure increase.

Farmers that perceive a negative impact of livestock on small grain acres are more likely to use IT, RT, and $RT_{0.5}$ methods. By changing the perception of a producer from negative impact to a no-impact of livestock on small grain production the proportion of farmers that will adopt CST and $CST_{0.5}$ did not change substantially, a decrease by one percent of the proportion of farmers that use IT, a decrease by one percent of the proportion of farmers that use RT, a decrease by two percent of the proportion of farmers that use $RT_{0.5}$, and an increase by two percent of the proportion of farmers that use OT.

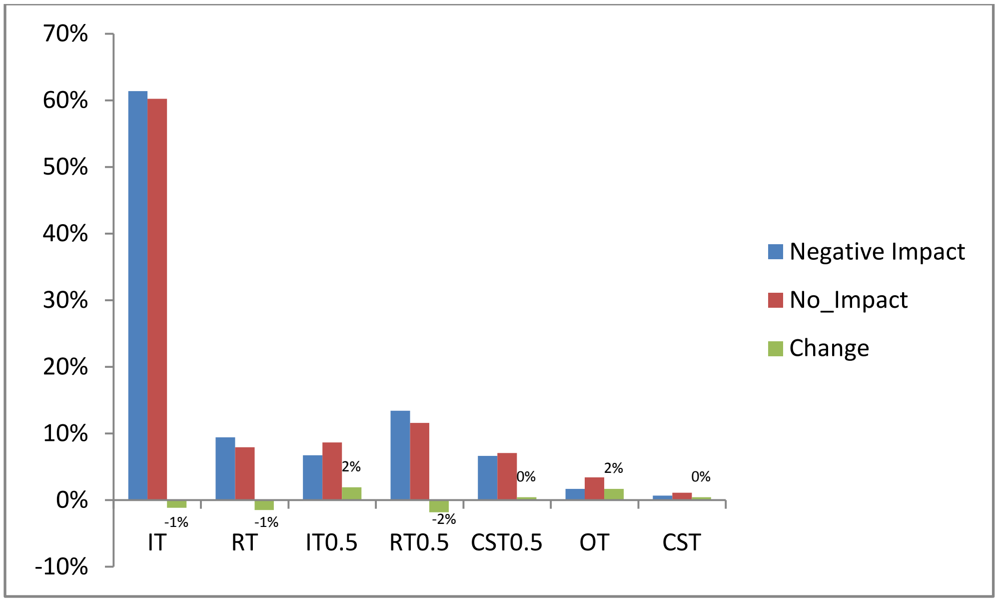


Figure IV-4. Effects of the perception of grazing impact on small grain acres.

Likewise, farmers that perceive erosion issue on their lands, farmers that think CST practices generate more profits, farmers that perceive CST as a means to reduce compaction, producers that think pest and insect pressure are not an issue, and farmers that think CST practices do not increase soil and plant disease are less likely to use IT practices and more likely to adopt CST methods.

By developing an environmentally viable rotation crop, by educating producers on the drawback of IT techniques and informing farmers the advantages of using CST, the percent of farmers using conservation tillage practices will increase.

Table IV-7 Definition and mean values of explanatory variables

Items	Definition	Mean Values
ACRES_FARMED	Number of acres planted to annual crops	863
KNOWLEDGE	Understanding of CST practices	6
CROPPING_SYSTEM (YES)	Cropping systems: crop rotation practices	38%
CROPPING_SYSTEM (NO)	Cropping systems: mono-crop practices	62%
IMPACT	Negative impact of livestock on small grain acres=1	35%
GRAIN_WHEAT	Small grain management systems: Grain only purpose	23%
FORAGE_WHEAT	Small grain management systems: Forage only purpose	12%
DUAL_WHEAT	Small grain management systems: Dual purpose	65%
EROSION_REDUC	CST practices reduce soil erosion	2
PROFITS_GREATER	CST practices generate greater profits	2
MOISTURE_SOIL	CST practices conserve soil moisture	2
COMPACTION [a]	CST practices reduce soil compaction	2
PEST_PRESS [a]	CST practices increase weed and insect pressure	2
DISEASES [a]	CST practices increase soil and plant disease	5
AGE	Producers' age group	55-65
EDUCATION	Producer highest education level	High school
EMPLOYMENT	Hours per week of off farm job	6-10hours
PROP_RENTED	Proportion of rented land to produce annual crops	67%

Table IV-8. Model two maximum likelihood parameter estimates

	IT	RT	$IT_{0.5}$	$RT_{0.5}$	$CST_{0.5}$	OT	CST
INTERCEPT	-7.012***	-1.101	-2.838	-3.96**	-3.087	-5.51***	0
AGE [a]	0.093	0.273	0.178	-0.080	0.0055	-0.195	0
KNOWLEDGE [a]	-0.262***	-0.098	-0.060	-0.125	-0.033	0.206**	0
BENEFITS [a]	-0.498***	-0.36**	0.134	-0.270	-0.137	0.384**	0
PROBLEMS [c]	0.203*	0.084	0.014	0.191	0.114	0.0056	0
PASSES [a]	1.878***	1.36***	2.262***	2.46***	2.27***	2.273***	0
ACRES_FARMED [b]	-0.559**	-0.66**	-0.197	-0.234	-0.352	-0.395	0
WHEAT_PRODUCTION (GO) [a]	0.438	-0.065	0.417	-0.173	0.350	0.391	0
WHEAT_PRODUCTION (FO) [a]	-0.280	-0.059	0.070	0.300	-0.141	0.121	0
CROPPING_SYSTEM (NO) [a]	0.352*	0.385**	0.167	0.131	0.099	-0.176	0
PROP_RENTED	0.096	0.324	-0.019	-0.004	-0.139	0.193	0
SALES [a]	0.077	0.187	0.034	0.25	0.375**	0.397**	0
SHARES [a]	-0.003	0.004	-0.015**	0.001	-0.003	-0.012	0
OFF_FARM_INCOME	-0.083	-0.058	-0.057	-0.117	-0.210*	-0.165	0
EMPLOYMENT	0.077	0.014	-0.0077	0.0772	0.0701	0.064	0
EDUCATION	0.255	0.231	0.244	0.323	0.295	0.421*	0
YEARS_TILLING [a]	1.760***	0.194	-0.278*	-0.043	-0.32**	-0.52***	0
Frequency	582	225	341	194	122	122	117

[a] Explanatory variable significance level at the one percent level (Type III fixed effect).
[b] Explanatory variable significance level at the five percent level (Type III fixed effect).
[c] Explanatory variable significance level at the ten percent level (Type III fixed effect).
[*] Maximum likelihood coefficient significance level at the one percent level.
[*] Maximum likelihood coefficient significance level at the five percent level.
[*] Maximum likelihood coefficient significance level at the ten percent level.

Table IV-9. Model one maximum likelihood parameter estimates

	IT	RT	IT0.5	RT0.5	CST0.5	OT	CST
Intercept	-94.3705	-87.7727	-90.7369	-90.5832	-91.0037	-92.9677	0
AGE [a]	3.0688	3.295	3.2689	2.8927	3.0945	2.8222	0
KNOWLEDGE [a]	0.1377	0.2776	0.3807	0.256	0.4236	0.6844	0
BENEFITS [a]	4.8982	4.908	5.5518	5.0776	5.3123	5.8084	0
PROBLEMS [b]	3.9055	3.7472	3.6456	3.8425	3.8583	3.6879	0
PASSES [a]	48.8394	48.1385	49.2706	49.4298	49.2577	49.292	0
ACRES_FARMED [c]	-0.9373	-1.3032	-0.5945	-0.7714	-0.9336	-0.9621	0
GRAIN_ONLY [a]	5.3126	4.4525	5.2	4.8721	5.0745	5.2873	0
FORAGE_ONLY [a]	-10.7502	-10.3812	-10.3582	-10.3623	-10.5241	-10.5641	0
CROP_ROTATION [a]	2.4448	2.4775	2.1445	2.2355	2.1615	1.8756	0
PROP_RENTED	3.3537	3.5009	3.3043	3.2066	2.813	3.3035	0
SALES [a]	-3.6444	-3.4188	-3.6389	-3.3854	-3.283	-3.3107	0
SHARES [a]	-0.1212	-0.1085	-0.1342	-0.1185	-0.1189	-0.1315	0
OFF_FARM_INCOME	-7.1865	-7.1387	-7.1971	-7.3031	-7.3313	-7.29	0
EMPLOYMENT	1.7614	1.7143	1.7233	1.8178	1.746	1.7284	0
EDUCATION	9.9381	9.9422	9.8969	10.1413	9.8985	10.029	0
YEARS_TILLING [a]	3.0457	1.5435	0.9564	1.1881	0.8816	0.7123	0
Frequency	396	162	245	155	96	106	86

[a] Explanatory variable significance level at the one percent level (Type III fixed effect).
[b] Explanatory variable significance level at the five percent level (Type III fixed effect).
[c] Explanatory variable significance level at the ten percent level (Type III fixed effect).

Table IV-10. Model three maximum likelihood parameter estimates

	IT	RT	IT0.5	RT0.5	CS0.5	OT	CST
Intercept	-7.6471	-1.7014	-3.3755	-4.8134	-3.6906	-5.6533	0
AGE [a]	0.1372	0.3	0.2276	-0.0224	0.0542	-0.1602	0
KNOWLEDGE [a]	-0.2972	-0.1413	-0.1021	-0.154	-0.0834	0.1485	0
BENEFITS [a]	-0.554	-0.3978	0.0984	-0.2747	-0.1633	0.3421	0
PROBLEMS [b]	0.2616	0.1515	0.0721	0.2634	0.1577	0.0459	0
PASSES [a]	1.7588	1.2854	2.1462	2.3344	2.1435	2.1533	0
ACRES_FARMED [c]	-0.4398	-0.5725	-0.0834	-0.1436	-0.294	-0.2841	0
GRAIN_ONLY [a]	0.3858	-0.1058	0.3568	-0.1891	0.2458	0.3453	0
FORAGE_ONLY [a]	-0.2977	-0.1017	0.0538	0.2272	-0.1415	0.0889	0
CROP_ROTATION [a]	0.4513	0.4734	0.2644	0.237	0.2038	-0.0865	0
PROP_RENTED	0.0819	0.2714	-0.1131	-0.0851	-0.2257	0.1309	0
SALES [a]	-0.0104	0.0949	-0.0539	0.1602	0.3129	0.2812	0
SHARES [a]	0.000827	0.00713	-0.0118	0.0031	0.00255	-0.00954	0
OFF_FARM_INCOME	-0.049	-0.0376	-0.0971	-0.1736	-0.2097	-0.1732	0
EMPLOYMENT	0.0736	0.0155	0.0125	0.1169	0.0886	0.0759	0
EDUCATION	0.3495	0.2994	0.3226	0.4063	0.3532	0.474	0
YEARS_TILLING [a]	1.8765	0.311	-0.1422	0.0971	-0.1765	-0.3885	0
Frequency	582	225	341	194	122	122	117

[a] Explanatory variable significance level at the one percent level (Type III fixed effect).
[b] Explanatory variable significance level at the five percent level (Type III fixed effect).
[c] Explanatory variable significance level at the ten percent level (Type III fixed effect).

Table IV-11. Model two marginal effects

		IT	RT	IT0.5	RT0.5	CST0.5	OT	CST
AGE [a]		-2.356	4.050	0.345	-0.589	-0.462	-0.304	-0.684
KNOWLEDGE [a]		-4.325	1.352	1.482	0.035	0.358	0.416	0.683
BENEFITS [a]		-7.872	-3.368	8.562	-0.033	0.419	0.919	1.372
PROBLEMS [c]		3.276	-1.098	-1.751	0.211	-0.014	-0.108	-0.517
PASSES [a]		1.926	-12.543	9.705	2.446	1.794	0.573	-3.903
ACRES_FARMED [b]		-3.350	-5.995	5.430	0.716	0.383	0.073	2.744
	GO	0.079	-0.097	0.034	-0.011	0.004	0.002	-0.010
WHEAT_ PRODUCTION[a]	FO	-0.064	0.016	0.031	0.011	-0.001	0.002	0.005
CROP_ROTATION [a]		0.021	0.031	-0.023	-0.005	-0.006	-0.005	-0.014
PROP_RENTED		-0.016	0.062	-0.028	-0.004	-0.009	0.001	-0.006
SALES [a]		-1.698	2.170	-1.546	0.371	0.927	0.320	-0.544
SHARES [a]		0.000	0.002	-0.002	0.000	0.000	0.000	0.000
OFF_FARM_INCOME		-0.418	0.440	0.267	-0.123	-0.419	-0.091	0.344
EMPLOYMENT		1.480	-0.774	-0.784	0.113	0.108	0.028	-0.170
EDUCATION		0.006	-0.002	0.001	0.002	0.002	0.002	-0.011
YEARS_TILLING [a]		39.960	-18.979	-12.971	-1.820	-2.402	-0.802	-2.986

CHAPTER V

FARMERS SPATIAL CHARACTERISTICS AND THE DECISION TO USE A TILLAGE PRACTICE IN OKLAHOMA

The choice of which tillage practice is more preferable for profit maximization depends on the decision maker, the location of the farm, and many other characteristics associated with the topology of the land and the climate. In this part, data do not allow to investigate how the land topology and the climate affect the use of tillage. The main objective is to determine how differences in the farm location affect the cultivation methods. The major hypothesis to test is that cultivation / tillage methods are different from one farmer to another within the same region and vary also across regions.

This part contains a summary of farms' characteristics by region and by tillage practices particularly the average number of acres planted to annual crop production; the proportion of acres seeded to wheat; the proportion of farms; the number of tillage passes; the wheat production system; the wheat cropping system; and the proportion of acres rented to produce annual crops.

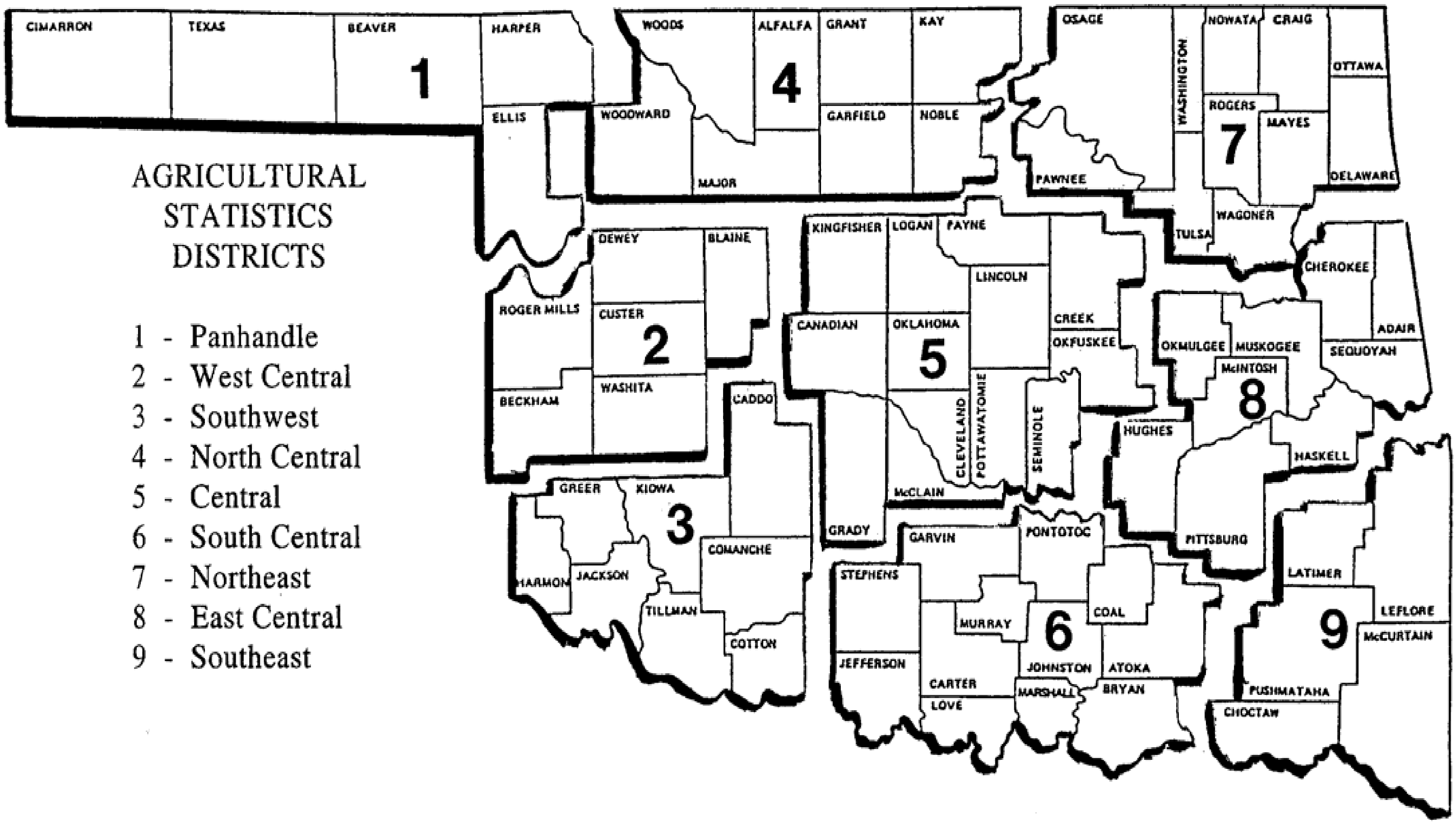
Additionally, this part reports the relationship between the dependent variable and the different explanatory variables via the maximum likelihood parameter estimates from a MNL model.

From the survey all regions included, the average IT acres of 585 is 27 percent less than the average CST acres of 744 but six percent greater than the average RT acres (table V-1). In these categories, producers can report crop acres under more than one tillage group; they are not exclusive categories. For simplicity in the rest of the analysis, categories were divided as in the previous chapter into pure users and partial users of a tillage practice. The lowest number of acres tilled on average using CST, IT, and RT across all regions are in South Central of respectively 268, 363, and 354 acres. The greatest number of acres tilled using CST is in the Panhandle, 1,028 acres. The Southwest region reported the highest average acres of RT, 700, across the seven regions; and producers in the North Central reported they use IT on 746 acres which the greatest of the regions.

Since producers in the South Central region reported on average the smallest acres under each tillage category, on average acres planted to annual crops regardless of the tillage practice will be the lowest across regions. On average 484 acres were planted to annual crops in the South Central region. Producers in the North Central region and in the Southwest region reported on average the highest acres planted to annual crops of respectively 1,063 acres and 1,009 acres. Noticeable differences in the proportions of acres by tillage categories were found. Of the total acres reported by producers in the survey, 43 percent were IT, 28 percent were RT, and 29 percent were CST. In the Central and West Central regions producers reported most of the acres were IT respectively 61 and 50 percent. Even though, the average acres tilled under each of the tillage categories were found in the South Central region, the proportion of acres under each tillage group shows that the Panhandle region and the East region had the lowest proportions of 29 percent each. The East region planted the greatest proportion of acres using CST (46 percent of acres reported by producers surveyed in that region); and alternatively the

Central region planted the lowest proportion of 15 percent of acres planted by producers surveyed in that region (table V-1).

Presentation



Source: Oklahoma Agricultural Statistics (2008)

Figure V-1. Agricultural Statistics Districts

Table V-1. Summary of acres intensively tilled, reduced tilled, acres tilled using conservation tillage and the number of respondents by region.

Location		Tillage system used on farm: Acres intensively tilled [a]	Acres reduced tilled [b]	Acres tilled using conservation tillage [c]	Total [d]
All regions	Number [e]	1,080	733	575	1,703
	Average [f]	585	550	744	859
	Total [g]	632,319	403,303	428,077	1,463,700
	Percent [h]	43%	28%	29%	100%
Panhandle region	Number	93	86	59	166
	Average	511	662	1,028	995
	Total	47,482	56,965	60,666	165,114
	Percent	29%	35%	37%	100%
West Central region	Number	199	118	74	289
	Average	496	377	731	683
	Total	98,706	44,515	54,124	197,345
	Percent	50%	23%	27%	100%
Southwest region	Number	167	143	114	300
	Average	582	700	924	1,009
	Total	97,225	100,128	105,323	302,676
	Percent	32%	33%	35%	100%
North Central region	Number	285	166	136	424
	Average	746[f]	689	912	1,063
	Total	212,489	114,339	123,986	450,812
	Percent	47%	25%	28%	100%
Central region	Number	206	125	80	300
	Average	616[f]	403	377	691
	Total	126,946	50,315	30,176	207,437
	Percent	61%	24%	15%	100%
South	Number	61[d]	38	37	94

Table V-1. Summary of acres intensively tilled, reduced tilled, acres tilled using conservation tillage and the number of respondents by region.

Location		Tillage system used on farm: Acres intensively tilled [a]	Acres reduced tilled [b]	Acres tilled using conservation tillage [c]	Total [d]
Central region	Average	363	354	268	484
	Total	22,157	13,463	9,918	45,539
	Percent	49%	30%	21%	100%
East region	Number	69	57	75	130
	Average	396	414	585	729
	total	27,314	23,578	43,884	94,777
	percent	29%	25%	46%	100%

[a] This includes several tillage passes and leaves less than 15 percent of residue on the soil surface after planting.
[b] One to three full width tillage passes and leaves 15-30 percent of residue on the soil surface after planting.
[c] Minimum soil disturbance; practices that fall under conservation tillage included strip-till, ridge-till, and vertical-till.
[d] Total of the item across the tillage systems.
[e] Number of farms in the category.
[f] Average number of acres planted to annual crops.
[g] Total number of acres planted to annual crops.
[h] Percent of acres planted to annual crops.

Table V-2 summarizes for each of the seven regions the proportion of farms that used IT exclusively, the proportion of farms that used CST exclusively, and the proportion of farms that used OT.

The number of farms used for the purpose is 1,703 of which ten percent were located in the Panhandle region, 17 percent in the West Central region, 18 percent in the Southwest region, 25 percent in the North Central region, 18 percent in the Central region, six percent in the South Central region, and eight percent in the East region (table V-2).

Table V-2. Summary of respondents that reported using intensive tillage exclusively, conservation tillage exclusively, and other tillage methods for each region.

		Tillage system used on farm			
Location	**Items**	**Intensive tillage exclusively [a]**	**Conservation tillage exclusively [b]**	**Other tillage [c]**	**Total**
All regions	Farms	582	117	1,004	1,703
	Percent of farms	34%	7%	58%	
Panhandle region	Farms	49	6	111	166
	Percent of farms	30%	4%	67%	10%
West Central region	Farms	112	22	155	289
	Percent of farms	39%	8%	54%	17%
Southwest region	Farms	79	28	193	300
	Percent of farms	26%	9%	64%	18%
North Central region	Farms	157	29	238	424
	Percent of farms	37%	7%	56%	25%
Central region	Farms	127	17	156	300
	Percent of farms	42%	6%	52%	18%
South Central region	Farms	30	6	58	94
	Percent of farms	32%	6%	62%	6%
East region	Farms	28	9	93	130
	Percent of farms	22%	7%	72%	8%

[a] Pure users of intensive tillage method. Producers in this category reported they planted all their annual crop acres using intensive tillage.
[b] Pure users of conservation tillage method. Producers in this category reported they planted all their annual crop acres using conservation tillage.
[c] Farmers that did not use intensive tillage exclusively and did not use conservation tillage exclusively.

The use of pure IT methods is more important in the Central and South Central regions. In the Central region the use of IT exclusively is the greatest among all regions and also the second lowest proportion of acres under CST exclusively is in the Central region. About a third (32 percent) of the acres planted to annual crops in the South Central region were exclusively tilled using pure IT methods while in the Central region up to 46 percent were tilled using exclusively IT methods (table V-3). In the West Central and North Central regions, a quarter of the acres planted to annual crops were tilled using exclusively IT methods. The use of exclusive IT methods is the lowest in the East region where only eight percent of the acres planted to annual crops in the regions were used under IT exclusively. In addition, producers in the Southwest and Panhandle regions have planted less proportion of their crop acres under pure CST respectively of 13 and 14 percent than the total average of 24 percent reported by all producers surveyed (table V-3). The highest proportion of acres planted to annual crops using CST exclusively is in the East region with 14 percent of the total acres; respectively 13 percent and 12 percent of the acres planted in Southwest and West Central regions were used under pure CST. In the Southwest region, the proportion of acres planted to annual crops using exclusively CST and exclusively IT are equal (13 percent each). The Panhandle region has the lowest proportion of their acres under pure CST among all regions; only 4 percent of the acres were under CST exclusively. Moreover, producers in the Central and South Central regions plant less proportion of their crop acres under pure CST respectively of five and seven percent less than the total average of 24 percent reported by all producers surveyed that use IT exclusively (table V-3).

Table V-3. Summary of the total acres planted to annual crops and their proportions by tillage methods for each region.

Location	Items	Tillage system used on farm: Intensive tillage exclusively [a]	Conservation tillage exclusively [b]	Other tillage [c]	Total
All regions	Total acres planted to annual crops	348,249.4	142,702.6	972,747.3	1,463,699
	Percent of acres planted to annual crops	24%	10%	66%	100%
Panhandle region	Total acres planted to annual crops	23,268	6,616	135,229	165,113
	Percent of acres planted to annual crops	14%	4%	82%	11%
West Central region	Total acres planted to annual crops	50,038	23,736	123,571	197,345
	Percent of acres planted to annual crops	25%	12%	63%	13%
Southwest region	Total acres planted to annual crops	40,135	38,927	223,614	302,676
	Percent of acres planted to annual crops	13%	13%	74%	21%
North Central region	Total acres planted to annual crops	117,851	45,777	287,185	450,813
	Percent of acres planted to annual crops	26%	10%	64%	31%
Central region	Total acres planted to annual crops	94,417	10,591	102,429	207,437
	Percent of acres planted to annual crops	46%	5%	49%	14%
South Central region	Total acres planted to annual crops	14,494	3,324	27,721	45,539
	Percent of acres planted to annual crops	32%	7%	61%	3%
East region	Total acres planted to annual crops	8,046	13,732	72,999	94,777
	Percent of acres planted to annual crops	8%	14%	77%	6%

[a] This includes several tillage passes and leaves less than 15 percent of residue on the soil surface after planting.
[b] One to three full width tillage passes and leaves 15-30 percent of residue on the soil surface after planting.
[c] Minimum soil disturbance; practices that fall under conservation tillage included strip-till, ridge-till, and vertical-till.
[d] Total across the tillage systems.

The East region planted to annual crops using IT exclusively on average 52 percent lower than the total average under IT exclusively reported by all regions.

The number of acres planted to annual crops using CST exclusively reported by farmers in the East region is 25 percent greater than the total average under CST exclusively reported by all regions. The Central and North Central regions planted to annual crops using IT exclusively more than the average IT exclusively reported by all regions. Only in the North Central region the average acres planted under CST exclusively is lower than the IT exclusively average acres (table V-4).

Table V-4. Summary of the average acres planted to annual crops by region.

	Tillage system used on farm			
Location	**Intensive tillage exclusively [a]**	**Conservation tillage exclusively [b]**	**Other tillage [c]**	**Average [d]**
All regions	598	1,220	971	859
Panhandle region	475	1,103	1,218	995
West Central region	447	1,079	797	683
Southwest region	508	1,390	1,159	1,009
North Central region	751	1,579	1,207	1,063
Central region	743	623	657	691
South Central region	483	554	478	484
East region	287	1,526	785	729

[a] This includes several tillage passes and leaves less than 15 percent of residue on the soil surface after planting.
[b] One to three full width tillage passes and leaves 15-30 percent of residue on the soil surface after planting.
[c] Minimum soil disturbance; practices that fall under conservation tillage included strip-till, ridge-till, and vertical-till.
[d] Average across the tillage systems.

Producers in the East region reported the lowest proportion of acres seeded to wheat under CST exclusively. Only 38 percent of the acres planted under CST exclusively were seeded to wheat while the total average acres seeded to wheat under CST reported by all producers in the survey is 67 percent (table V-5). The results also suggest that wheat production is not as popular in that region as in the others. About 54 percent of the East region was seeded to wheat compared to 85 percent across all regions (table V-5). This implies that there is more crop diversification in the East region relative to other regions. The West Central region producers reported the highest proportion of acres seeded to wheat (91 percent). The highest proportion of acres seeded to wheat using IT exclusively is in the West Central and North Central regions where producers reported 96 percent of acres were planted for wheat production. Half (51 percent) of CST exclusively acres planted to annual crops in the North Central region was seeded to wheat which was the second lowest proportion across regions. Despite the fact that the lowest proportion seeded to wheat under IT exclusively across all regions was in the Panhandle region (85 percent), about 88 percent of the CST exclusively acres in that region were seeded to wheat and the highest reported across all regions (table V-5). Only half of CST exclusively acres planted to annual crops in the North Central region (51 percent) was seeded to wheat which was the second lowest proportion across regions.

Table V-5. Summary of the proportion of acres Seeded to Wheat by Region by Tillage System

	Tillage system used on farm			
Location	**Intensive tillage exclusively [a]**	**Conservation tillage exclusively [b]**	**Other tillage [c]**	**Total**
All regions	92.50%	66.80%	79.90%	85%
Panhandle region	85%	88%	70%	73%
West Central region	96%	81%	91%	91%
Southwest region	91%	81%	76%	79%
North Central region	96%	51%	86%	85%
Central region	95%	76%	85%	89%
South Central region	70%	65%	86%	79%
East region	70%	38%	56%	54%

[a] Pure users of intensive tillage method. Producers in this category reported they planted all their annual crop acres using intensive tillage.
[b] Pure users of conservation tillage method. Producers in this category reported they planted all their annual crop acres using conservation tillage.
[c] Farmers that did not use intensive tillage exclusively and did not use conservation tillage exclusively.

There was not much difference in the number of tillage passes across regions. On average, 3.8 tillage passes under IT, 2.1 tillage passes under RT, and 0.5 tillage passes under CST (table V-6).

Table V-6. Summary of number of tillage passes for each region

	Tillage system used on farm		
Location	**Intensive tillage [a]**	**Reduced tillage [b]**	**Conservation tillage [c]**
All regions	3.8	2.1	0.5
Panhandle region	3.4	1.9	0.5
West Central region	3.7	2.0	0.4
Southwest region	3.9	2.2	0.5
North Central region	4.0	2.3	0.5
Central region	3.8	2.1	0.6
South Central region	3.7	2.0	0.5
East region	3.6	1.8	0.6

[a] This includes several tillage passes and leaves less than 15 percent of residue on the soil surface after planting.

[b] This includes one to three full width tillage passes and leaves 15-30 percent of residue on the soil surface after planting.

[c] Minimum soil disturbance; practices that fall under conservation tillage included strip-till, ridge-till, and vertical-till.

Table V-7. Summary of wheat production systems by region.

Location	Items	Respondents	Average	Total	Percent
All regions	Grain only [a]	388	738	286,500	24%
	Forage only [b]	194	369	71,521	8%
	Dual Purpose [c]	1,073	780	836,910	68%
Panhandle region	Grain only	60	781	46,872	39%
	Forage only	15	247	3,704	3%
	Dual Purpose	83	833	69,134	58%
West Central region	Grain only	39	721	28,107	16%
	Forage only	21	510	10,709	6%
	Dual Purpose	221	637	140,803	78%
Southwest region	Grain only	65	888	57,727	24%
	Forage only	21	214	4,498	2%
	Dual Purpose	212	833	176,597	74%
North Central region	Grain only	133	810	107,787	28%
	Forage only	15	494	7,407	2%
	Dual Purpose	267	1,007	268,893	70%
Central region	Grain only	40	471	18,842	10%
	Forage only	46	352	16,172	9%
	Dual Purpose	206	728	150,012	81%
South Central region	Grain only	7	502	3,515	10%
	Forage only	54	374	20,211	56%
	Dual Purpose	25	497	12,432	34%
East region	Grain only	44	538	23,650	46%
	Forage only	22	401	8,820	17%
	Dual Purpose	59	323	19,038	37%

[a] Winter wheat planted in late October for grain only purpose.
[b] Winter wheat planted in early September and grazed from November and may continue until May.
[c] Winter wheat planted in early September and grazed from November until just before the first hollow stem apparition usually in late February.

Tables V-7 and V-8 summarize the wheat production systems by region. Table V-7 is a summary of the number of respondents and the average acres of grain only (GO) wheat, forage only (FO) wheat, and dual purpose (DP) wheat. In table V-8, the summary is in percent of wheat acres by tillage system and by region. The average wheat acres for GO purpose is the lowest in the Central region of 471acres which is 36 percent lower than the survey wheat acres for GO purpose. The South Central region and the East region reported about 32 percent and 27 percent lower than the survey average wheat acres for GO purpose. The average of 1,007 wheat acres seeded for DP is 29 percent greater than the average reported in the survey of 780 acres (table V-7).

In the East region, only 37 percent of wheat acres were for DP which is less than the 68 percent reported by all farmers. However, GO and FO activities, respectively 46 percent and 17 percent in the East region, were more important than those in the survey by all respondents of respectively 24 percent and 8 percent (table V-8). The South Central region reported the lowest proportions of their wheat acres under GO (ten percent) and DP (34 percent) and also the highest proportion under FO (56 percent) across all regions (table V-8). In the West Central, Southwest, and Panhandle regions the proportions of FO wheat acres were the lowest.

Table V-8. Summary of wheat production system by tillage system (% of acres) and by region.

Location	Items	Tillage system used on farm: Intensive tillage exclusively [a]	Tillage system used on farm: Conservation tillage exclusively [b]	Tillage system used on farm: Other tillage [c]	Total Percent
All regions	Grain only [a]	21% [e]	37%	24%	24% [f]
	Forage only [b]	6%	9%	8%	8%
	Dual purpose [c]	73%	54%	68%	68%
Panhandle region	Grain only	10%	3%	87%	39%
	Forage only	57%	0%	43%	3%
	Dual Purpose	19%	6%	75%	58%
West Central region	Grain only	32%	7%	61%	16%
	Forage only	22%	3%	75%	6%
	Dual Purpose	26%	12%	62%	78%
Southwest region	Grain only	15%	14%	70%	24%
	Forage only	36%	4%	60%	2%
	Dual Purpose	15%	13%	72%	74%
North Central region	Grain only	33%	15%	52%	28%
	Forage only	16%	0%	84%	2%
	Dual Purpose	29%	3%	69%	70%
Central region	Grain only	23%	10%	68%	10%
	Forage only	23%	8%	69%	9%
	Dual Purpose	54%	3%	42%	81%
South Central region	Grain only	54%	31%	14%	10%
	Forage only	31%	5%	63%	56%
	Dual Purpose	15%	0%	85%	34%
East region	Grain only	12%	19%	68%	46%
	Forage only	4%	0%	96%	17%
	Dual Purpose	12%	4%	84%	37%

[a] Winter wheat planted in late October for grain only purpose.
[b] Winter wheat planted in early September and grazed from November and may continue until May.
[c] Winter wheat planted in early September and grazed from November until just before the first hollow stem apparition usually in late February.

The average acres rented for annual crop production in the Panhandle region of 862 is the greatest across all regions followed by the North Central and West Southwest regions where producers reported they rent 830 acres and 784 acres, respectively (table V-9). Only in these three regions the average acres rented and as a result the proportions of acres rented to produce annual crops were greater than the overall survey average acres rented of 665 acres which represent a proportion of 53 percent (table V-9). The lowest average acres rented were in the South Central and Central region with respectively 398 acres (40 percent less than survey average acres rented) and 461 acres (31 percent less than survey average acres rented).

Table V-9. Summary of farms 'characteristics of land rented to produce annual crops by tillage system and by region

Location	**Zero land rented** [a]	**Farms that rented land** [b]	**Average acres rented** [c]	**Proportion of acres rented** [d]
All regions	32%	68%	665	53%
Panhandle region	27%	73%	862	63%
West Central region	31%	69%	500	50%
West Southwest region	30%	70%	784	54%
North Central region	29%	71%	830	55%
Central region	34%	66%	461	44%
South Central region	46%	54%	398	45%
East region	35%	65%	532	48%

[a] Proportion of farmers that reported they did not rent any land for annual crop production.
[b] Proportion of farmers that reported they rented land to produce annual crops.
[c] Average acres rented by farmers that rent lands to produce annual crops.
[d] This is the ratio of land rented reported by farmers in the location over the total acres reported by farmers in the same location.

A summary of average acres rented across regions and by tillage is reported in table V-10. A summary of acres farmed by tillage systems and across regions is reported in table V-1. In some cases, the average acres rented in table V-10 is greater than the average acres farmed in table V-1. This is because in table V-10, the average acres rented is only for farmers that reported they rent some acres, while the average acres farmed in table V-1 includes farmers that rent as well as those that did not rent any lands.

Table V-10. Summary of farms 'characteristics of land rented to produce annual crops by tillage system and by region

Location	Item	Intensive tillage exclusively [a]	Conservation tillage exclusively [b]	Other tillage [c]
All regions	Zero land rented [d]	40%	27%	26%
	Proportion of acres rented [e]	48%	54%	57%
	Average acres rented [f]	478	721	941
Panhandle region	Zero land rented	33%	25%	20%
	Proportion of acres rented	68%	62%	72%
	Average acres rented	482	950	950
West Central region	Zero land rented	40%	23%	45%
	Proportion of acres rented	50%	53%	37%
	Average acres rented	370	550	736
West Southwest region	Zero land rented	43%	26%	18%
	Proportion of acres rented	58%	52%	65%
	Average acres rented	520	817	1,098
North Central region	Zero land rented	40%	23%	21%
	Proportion of acres rented	49%	57%	63%
	Average acres rented	610	890	1,254
Central region	Zero land rented	39%	29%	35%
	Proportion of acres rented	35%	494%	6%
	Average acres rented	427	475	553

Table V-10. Summary of farms 'characteristics of land rented to produce annual crops by tillage system and by region

Location	Item	Intensive tillage exclusively [a]	Conservation tillage exclusively [b]	Other tillage [c]
South Central region	Zero land rented	50%	47%	17%
	Proportion of acres rented	51%	44%	24%
	Average acres rented	490	392	157
East region	Zero land rented	46%	33%	11%
	Proportion of acres rented	48%	47%	54%
	Average acres rented	257	548	920

[a] Pure users of intensive tillage method. Producers in this category reported they planted all their annual crop acres using intensive tillage.
[b] Pure users of conservation tillage method. Producers in this category reported they planted all their annual crop acres using conservation tillage.
[c] Farmers that did not use intensive tillage exclusively and did not use conservation tillage exclusively.
[d] Proportion of farmers that reported they did not rent any land for annual crop production.
[e] This is the ratio of land rented reported by farmers in the location over the total acres reported by farmers in the same location.
[f] Average acres rented by farmers that rent lands to produce annual crops. A summary of acres farmed by tillage systems and across regions is reported in table V-1. In some cases, the average acres rented in table V-10 is greater than the average acres farmed in table V-1. This is because in table V-10, the average acres rented is only for farmers that reported they rent some acres, while the average acres farmed in table V-1 includes farmers that rent as well as those that did not rent any lands.

Half of on-farm income from crop and livestock sales is from crops sales. In the South Central region only 26 percent of on-farm income from crop and livestock sales is from crop sales.

Table V-11. Summary of split of farm income between crop and livestock sales by region.

Location	Crop	Livestock
All regions	50%[a]	50%[b]
Panhandle region	60%	40%
West Central region	46%	54%
West Southwest region	51%	49%
North Central region	61%	39%
Central region	43%	57%
South Central region	26%	74%
East region	46%	54%

[a] Proportion of crop sales in farm income between crop and livestock sales.
[b] Proportion of livestock sales in farm income between crop and livestock sales.

By region likelihood parameters estimates

To be able to analyze the data by region, a likelihood ratio test was conducted to test whether the data are separable. Seven regions are represented in this study: Panhandle region (PR); West Central region (WCR); West Southwest region (WSR); North Central region (NCR); Central region (CR); South Central region (SCR); East region (ER).

The probability of choosing an alternative tillage j is given by:

(IV-1) $$P(Tillage_j) = P(U_{ij} > U_{ik}\ for\ all\ j \neq k)$$

The producer utility function for alternative tillage practice j is given by:

(IV-2) $$P_{ij} = \frac{exp(\beta_j X_i)}{\sum_{k=1}^{m=7} exp(\beta_k X_i)}$$

The producer utility function for alternative tillage practice j is given by:

(IV-3) $$U_{ij} = V_{ij} + \varepsilon_{ij}, \text{ where } V_{ij} = \beta_j X_{ij}$$

i: subscript for producer j: alternative tillage practice

for region r:

$$(IV-4) \quad V_j^r = \beta_0^r + \beta_1^r * (\text{AGE})_j + \beta_2^r * (\text{KNOWLEDGE})_j + \beta_3^r * (\text{BENEFITS})_j + \beta_4^r * (\text{PROBLEMS})_j + \beta_5^r * (\text{PASSES})_j + \beta_6^r * (\text{ACRES\_FARMED})_j + \beta_7^r * (\text{WHEAT\_ PRODUCTION})_j + \beta_8^r * (\text{CROP\_ROTATION})_j + \beta_9^r * (\text{PROP\_RENTED})_j + \beta_{10}^r * (\text{SALES})_j + \beta_{11}^r * (\text{SHARES})_j + \beta_{12}^r * (\text{OFF\_FARM\_INCOME})_j + \beta_{13}^r * (\text{EMPLOYMENT})_j + \beta_{14}^r * (\text{EDUCATION})_j + \beta_{15}^r * (\text{YEARS\_TILLING })_j$$

The log likelihood functions for the multinomial logistic model are given by:

(IV-5) $$LogL = \sum_{i=1}^{N=1703} \sum_{j=1}^{J=7} \gamma_{ij} * ln\left[P\left(Tillage_j\right)\right]$$

Where N is the number of producers in the survey, i is the ith individual, j is the jth alternative tillage methods, γ_{ij}a dummy variable that takes one if the producer chooses an alternative j and zero otherwise, ln is the natural logarithm, and P(Tillage_j) is the probability that a producer will choose a tillage practice.

The likelihood ratio test consists of testing the parameters across regions. For each region r, there is a likelihood coefficient. The pooled data represent the restricted model and the seven regions models represent the unrestricted models. The sum of the unrestricted likelihood coefficients subtracted from the restricted likelihood follows a χ^2 distribution.

Hypothesis testing

$H_0: \beta_0^1 = \beta_0^2 = \cdots = \beta_0^5, \beta_1^1 = \beta_1^2 = \cdots = \beta_1^5, \ldots, \beta_{15}^1 = \beta_{15}^2 = \cdots = \beta_{15}^5$ all corresponding parameter estimates are equal across regions.

H_a: at least one of the parameters is different from the corresponding ones.

Test statistics

$$\chi^2_{statistics} = (-2LogL_{restricted}) - [(-2LogL_{region1}) + \cdots + (-2LogL_{region7})]$$

$$= 4346.09$$

$$- (330.26 + 597.81 + 700.67 + 894.87 + 605.38 + 132.28 + 219.67)$$

$$= 865.15$$

$$\chi^2_{critic} = \chi^2_{(16*6, 0.05)} = 119.8$$

($\chi^2_{[\text{number of parameters}*(\text{number of regions}-1)]}$)= χ^2_{critic}

Initial decision

$$\chi^2_{critic} < \chi^2_{statistics}$$

Decision

Reject the null hypothesis that all corresponding parameter estimates are the same across regions. This suggests that at least one of the equivalent maximum likelihood estimates is different and thus data can be analyzed for each region individually.

Table V-12. Restricted and unrestricted likelihood coefficients

	Regions							
	PR	WCR	WSR	NCR	CR	SCR	ER	AR
-2LOGL	330.26	597.81	700.67	894.87	605.38	132.28	219.67	4346.09
	Unrestricted models							Restricted model

Panhandle region (PR); West Central region (WCR); West Southwest region (WSR); North Central region (NCR); Central region (CR); South Central region (SCR); East region (ER); All regions (AR).

Following are the results from the by-region maximum likelihood parameter estimates.

Table V-13. Summary of number of respondents by-region and by tillage category

	PR	WCR	WSR	NCR	CR	SCR	ER	AR
IT	49	112	79	157	127	30	28	582
RT	26	36	43	59	40	10	11	225
$IT_{0.5}$	37	54	65	72	50	23	40	341
$RT_{0.5}$	15	34	26	63	32	14	10	194
$CST_{0.5}$	18	17	34	20	19	4	10	122
OT	15	14	25	24	15	7	22	122
CST	6	22	28	29	17	6	9	117
Total	166	289	300	424	300	94	130	1703

Panhandle region (PR); West Central region (WCR); West Southwest region (WSR); North Central region (NCR); Central region (CR); South Central region (SCR); East region (ER); All regions (AR).

Table V-14. The Panhandle region maximum likelihood parameter estimates

	CT	RT	CT0.5	RT0.5	NT0.5	OT	CST
Intercept	-32.18	-19.84	-21.40	-26.91	-22.22	-28.10	0
AGE [a]	3.97	4.44	3.99	4.29	3.56	3.29	0
KNOWLEDGE [c]	3.59	3.90	3.82	4.16	4.24	4.43	0
BENEFITS	-4.68	-4.34	-3.99	-5.02	-4.72	-3.98	0
PROBLEMS a	0.75	0.34	0.26	1.07	1.02	0.46	0
PASSES	11.67	11.30	12.09	12.50	12.18	12.13	0
ACRES_FARMED	2.22	2.05	2.38	1.94	2.04	1.82	0
GRAIN_ONLY	-3.73	-3.01	-3.11	-3.24	-3.19	0.50	0
FORAGE_ONLY	10.19	9.42	9.77	9.15	9.21	2.60	0
CROP_ROTATION	-1.63	-1.92	-1.92	-1.26	-2.47	-1.72	0
PROP_RENTED	5.70	4.24	4.21	3.74	3.41	5.36	0
SALES	-1.38	-1.16	-0.54	-0.40	-0.87	-0.13	0
SHARES	0.03	0.03	0.04	0.05	0.05	0.05	0
OFF_FARM_INCOME	-2.10	-1.85	-1.98	-2.59	-3.38	-3.10	0
EMPLOYMENT	2.05	2.14	2.11	2.16	2.82	2.48	0
EDUCATION	-1.77	-0.95	-1.86	-0.77	-1.00	-0.93	0
YEARS_TILLING	2.61	-1.21	-0.89	-1.14	-1.16	-1.51	0

Table V-15. The West Central region maximum likelihood parameter estimates

	CT	RT	CT0.5	RT0.5	NT0.5	OT	CST
Intercept	-6.01	-3.02	-5.01	-9.10	-6.35	1.84	0
AGE	0.39	0.57	0.89[c]	0.76	0.87	-0.28	0
KNOWLEDGE	-0.03	0.11	0.00	-0.03	0.10	0.30	0
BENEFITS [c]	-0.51	-0.20	-0.03	-0.23	-0.13	-0.09	0
PROBLEMS	0.48	0.43	0.37	0.64	0.57	-0.30	0
PASSES [a]	2.22[a]	1.45[a]	3.02[a]	3.35[a]	3.05[a]	2.98[a]	0
ACRES_FARMED	-2.31[a]	-2.46[b]	-2.14[b]	-2.09[b]	-2.38[b]	-2.27[b]	0
GRAIN_ONLY	1.94	1.33	1.49	0.27	2.08	-0.55	0
FORAGE_ONLY	-0.46	-1.06	0.38	1.06	-0.71	2.07	0
CROP_ROTATION	0.52	0.11	0.74	0.44	0.95	-0.06	0
PROP_RENTED	2.49	3.40[c]	2.58	3.14[c]	1.86	4.63[b]	0
SALES	-0.22	-0.64	-0.44	0.15	0.30	-0.16	0
SHARES	-0.02	-0.01	-0.03	-0.01	-0.04	0.01	0
OFF_FARM_INCOME	-0.30	-0.14	-0.31	-0.11	-0.27	-0.70	0
EMPLOYMENT	0.07	-0.24	0.13	0.05	0.23	0.27	0
EDUCATION	0.05	0.07	0.14	0.28	-0.17	-0.23	0
YEARS_TILLING [a]	1.36[b]	0.28	-0.57	-0.72[c]	-0.92[b]	-1.65[a]	0

Table V-16. The West Southwest region maximum likelihood parameter estimates

	CT	RT	CT0.5	RT0.5	NT0.5	OT	CST
Intercept	2.22	7.14	8.36	6.60	7.40	-5.60	0
AGE [c]	0.20	-0.05	-0.26	-0.45	-0.63	-0.55	0
KNOWLEDGE [a]	-0.70[a]	-0.50[b]	-0.59[b]	-0.79[a]	-0.40	-0.01	0
BENEFITS [a]	-0.62	-0.56	0.04	-0.36	-0.15	0.81[c]	0
PROBLEMS	-0.39	-0.23	-0.56[c]	-0.39	-0.40	-0.14	0
PASSES [a]	1.70[a]	1.04[b]	1.99[a]	2.20[a]	1.96[a]	1.99[a]	0
ACRES_FARMED	-0.46	-0.64	0.33	-0.02	-0.89	-0.47	0
GRAIN_ONLY	-0.85	-0.68	-0.53	-1.65	-0.80	3.23	0
FORAGE_ONLY	0.85	0.88	0.69	1.26	1.11	-6.47	0
CROP_ROTATION	0.57	0.93[b]	0.73	0.33	0.86[c]	0.41	0
PROP_RENTED	0.78	0.63	0.15	0.42	0.33	0.73	0
SALES [b]	-0.38	0.11	-0.23	0.19	0.62	0.47	0
SHARES [a]	0.01	0.00	-0.02	0.02	0.03	-0.01	0
OFF_FARM_INCOME	-0.13	-0.59[c]	-0.09	0.08	-0.08	-0.41	0
EMPLOYMENT	0.06	0.27	-0.03	-0.26	-0.18	0.28	0
EDUCATION	-0.48	0.07	-0.24	-0.39	-0.52	-0.29	0
YEARS_TILLING [a]	1.43[a]	0.28	-0.49	-0.24	-0.50	-0.51	0

Table V-17. The North Central region maximum likelihood parameter estimates

	CT	RT	CT0.5	RT0.5	NT0.5	OT	CST
Intercept	-5.92	6.23	4.55	4.32	0.62	3.17	0
AGE [b]	-0.16	0.36	0.19	-0.32	-0.24	-0.31	0
KNOWLEDGE [b]	-1.40	-1.21	-1.17	-1.28	-1.29	-1.16	0
BENEFITS [a]	-2.13[c]	-2.06[c]	-1.48	-1.81	-1.70	-1.20	0
PROBLEMS	1.76	1.46	1.72	1.65	1.83	1.52	0
PASSES [a]	5.46[c]	4.87	6.15[c]	6.14[c]	5.96[c]	6.10[c]	0
ACRES_FARMED	-2.26	-2.80	-1.94	-2.09	-1.64	-1.77	0
GRAIN_ONLY [a]	-2.01	-3.12	-2.33	-2.45	1.06	-2.42	0
FORAGE_ONLY	3.54	3.84	4.68	3.86	-2.57	5.38	0
CROP_ROTATION	1.78	1.82	1.46	1.57	1.51	1.03	0
PROP_RENTED	2.89	3.03	3.44	3.29	4.51	2.80	0
SALES	2.22	2.46	2.25	2.51	2.43	2.70	0
SHARES	-0.08	-0.06	-0.09	-0.08	-0.09	-0.07	0
OFF_FARM_INCOME	-0.04	0.02	-0.18	-0.22	-0.05	-0.05	0
EMPLOYMENT	1.01	0.96	0.89	1.16	0.97	0.96	0
EDUCATION	2.26	1.77	2.08	2.22	2.40	2.46	0
YEARS_TILLING [a]	3.63[b]	0.90	-0.32	0.41	-0.17	-0.53	0

Table V-18. The Central region maximum likelihood parameter estimates

	CT	RT	CT0.5	RT0.5	NT0.5	OT	CST
Intercept	-23.93[b]	-16.53[b]	-14.73[c]	-17.21[b]	-19.76[b]	-26.94[a]	0
AGE	-0.02	0.78	-0.04	-0.03	-0.02	-0.09	0
KNOWLEDGE	-0.44	-0.23	-0.25	-0.22	-0.30	0.26	0
BENEFITS	-0.53	-0.37	0.08	-0.36	0.06	1.30[b]	0
PROBLEMS	1.07[b]	0.73[c]	1.26[a]	1.34[a]	1.04[b]	0.18	0
PASSES [a]	2.46[a]	1.39[b]	3.06[a]	3.28[a]	3.18[a]	3.16[a]	0
ACRES_FARMED	-0.37	-0.32	-0.32	0.10	-0.40	-1.81	0
GRAIN_ONLY	1.63	0.79	2.01	1.06	1.86	0.56	0
FORAGE_ONLY	-1.86	-1.02	-1.68	-0.84	-1.27	-0.29	0
CROP_ROTATION	-0.06	0.90	-0.38	-0.35	-0.09	-0.13	0
PROP_RENTED	-1.76	-0.88	-1.92	-2.29	-2.12	-0.46	0
SALES	1.66[c]	1.87	1.34	1.54	1.87[c]	1.82[c]	0
SHARES	-0.02	0.01	-0.04	-0.02	-0.02	-0.05	0
OFF_FARM_INCOME	0.68	0.41	0.58	0.91	0.29	0.78	0
EMPLOYMENT	-0.07	0.24	-0.11	-0.16	-0.24	-0.08	0
EDUCATION	0.96	1.07	1.33	1.22	2.00[c]	1.94[c]	0
YEARS_TILLING	3.45[a]	0.88	0.00	0.13	0.55	0.56	0

Table V-19. The South Central region maximum likelihood parameter estimates

	CT	RT	CT0.5	RT0.5	NT0.5	OT	CST
Intercept	-121.00	-110.10	-118.00	-127.20	6.76	-128.20	0
AGE	4.49	3.40	4.91	3.97	5.33	5.37	0
KNOWLEDGE [b]	0.96	0.93	1.20	1.18	3.55	0.89	0
BENEFITS [b]	0.04	0.71	1.34	0.94	-12.17	4.59	0
PROBLEMS	2.26	1.74	1.55	2.10	5.79	1.43	0
PASSES	9.99	8.35	9.73	10.84	1.34	10.70	0
ACRES_FARMED	6.09	5.99	4.53	5.13	15.39	-6.92	0
GRAIN_ONLY	-8.93	-16.64	-10.60	-10.62	0.94	-11.89	0
FORAGE_ONLY	-0.96	3.56	-0.40	-1.18	-8.34	-2.36	0
CROP_ROTATION	1.60	0.87	1.15	0.95	-1.11	0.38	0
PROP_RENTED	-1.05	0.35	0.73	0.24	-52.32	-2.93	0
SALES	2.73	2.84	2.66	3.09	3.53	3.30	0
SHARES	0.07	0.08	0.03	0.08	0.11	0.00	0
OFF_FARM_INCOME	5.96	6.34	7.04	5.96	5.72	8.23	0
EMPLOYMENT	-1.08	-1.70	-1.71	-0.61	5.99	-0.81	0
EDUCATION [c]	1.21	1.05	0.77	0.68	-21.54	1.63	0
YEARS_TILLING [b]	8.09	6.79	6.30	7.78	-5.92	3.75	0

Table V-20. The Northeast, East Central, and Southeast region maximum likelihood parameter estimates

	CT	RT	CT0.5	RT0.5	NT0.5	OT	CST
Intercept	31.11	26.40	27.14	27.06	7.09	30.52	0
AGE [a]	0.25	0.58	1.09	1.24	2.26	0.78	0
KNOWLEDGE [a]	-5.48	-5.01	-4.81	-5.31	-5.04	-4.24	0
BENEFITS [a]	-4.42	-4.34	-2.95	-3.56	-3.30	-3.25	0
PROBLEMS [c]	1.56	0.91	1.38	1.05	1.77	1.24	0
PASSES [a]	7.29	6.28	7.27	7.63	7.23	7.49	0
ACRES_FARMED [b]	-2.38	2.12	1.81	3.97	4.19	1.87	0
GRAIN_ONLY [a]	-10.61	-12.40	-11.89	-12.29	-13.39	-11.64	0
FORAGE_ONLY [a]	18.04	19.01	19.02	19.19	19.65	18.85	0
CROP_ROTATION	0.90	0.26	0.99	0.52	-1.57	-0.05	0
PROP_RENTED [a]	-2.51	-0.16	-2.69	-2.67	-6.42	-3.09	0
SALES [a]	-4.31	-3.12	-3.13	-3.15	-3.26	-2.92	0
SHARES	0.05	0.03	0.06	0.05	0.10	0.04	0
OFF_FARM_INCOME	1.67	2.21	1.71	1.35	2.85	1.00	0
EMPLOYMENT[a]	-4.93	-5.37	-5.34	-5.07	-5.30	-5.29	0
EDUCATION	2.42	4.31	2.55	1.71	0.09	3.04	0
YEARS_TILLING	8.28	6.64	4.67	5.58	7.19	3.50	0

CHAPTER VI

CONCLUSION

The objective of this thesis is to determine the characteristics of Oklahoma producers' different tillage systems; the proportion of farmers that use IT; the proportion that use RT; and the proportion that use CST. Additional objectives include identifying the relationship between producers and farms characteristics and the use of tillage by determining how personal/behavioral characteristics affect the choice of tillage practices; how physical characteristics affect the choice of tillage practices; how financial/economic characteristics affect the choice of tillage practices; and how producers' perception on CST affects the use tillage practices.

The average acres planted to annual crops is 585 acres for IT farms of which on average 89 percent of the acres were seeded to wheat, CST farmers plant an average of 744 acres of which 67 percent of the acres were planted to wheat, and 85 percent of the average RT of 552 acres were for wheat production. The average number of acres planted by the exclusive IT farms is less than the average number of acres planted by the CST farms. About a third of farmers did not report they rent land. The average number of acres rented by the exclusive IT farms (297) is less than the average number of acres rented by the CST farms.

IT producers practice more tillage passes on their farms than RT producers which also reported more tillage passes than CST producers. IT producers use more likely a tandem disk, an offset disk, a chisel plow, a sweep plow, a moldboard plow, a field cultivator, a single and a double disk drill, a hoe drill, and an anhydrous applicator than CST producers. The CST group uses more likely than the IT group an air seeder, a row crop planter, a sprayer, and a wet fertilizer spreader.

About a quarter of producers reported they seeded wheat for GO purpose, 13 percent for FO, and 64 percent for DP. Two fifths of producers practice a crop rotation system on their farm while three fifth do not practice a crop rotation system. The survey confirms that crop rotations are not common in the state. It is likely that the lack of an economically competitive crop to rotate with winter wheat hinders the use of CST in the state. Alternative winter small grain crops such as oats, barley, and rye are not economically competitive. Summer crops such as corn, soybeans, and grain sorghum do not fit well in a rotation with winter wheat and do not consistently perform well in the climate, which is characterized by hot, dry, windy summers. Compared to IT producers, there is evidence that CST producers rotated their crops more frequently. This will break cycles of weed, disease, and insect pressure by creating a more suitable environment for conservation tillage methods. CST producers operate on larger farm size than IT farmers.

Only three percent of the farmers were less than 34 while 70 percent were older than 55 which is consistent with the USDA/NASS (2007) report. The data show that farmers in the CST group are younger. The results suggest that the older the farmer the more reticent he is to use CST. Additionally, the return on investments required in machinery for successful CST may require a longer time horizon. Fifty percent of the respondents reported a high school education level (9 to 12 years of school). Only two percent reported less than nine years (grade school) of education. The remaining 48 percent indicated that they attended college.

Half of farmers reported crop and livestock sales less than $100,000 a year on average. Only 11 percent reported over half a million dollars in crop and livestock sales in an average year. The remaining 29 percent and ten percent of farmers reported respectively crop and livestock sales between $100,000 and $250,000, and between $250,000 and $500,000. The approximate split of on-farm income between crop and livestock sales is fifty-fifty. Farms in the CST group were more likely to report crop sales exclusively. On average the farms in the CST group are larger and report more sales.

The majority of farmers reported not working off-farm. About 63 percent of the respondents indicated that they do not have off-farm employment. The highest proportion of producers who do not have an off farm job is under CST. Approximately, two-fifths of farmers reported a zero percent of their income coming from off-farm while a fifth of farmers reported off-farm income to represent 75 percent of their income.

The use of exclusive IT methods is more important in the Central and South Central regions. In the Central region the use of IT exclusively is the greatest among all regions and also has the second lowest proportion of acres under CST exclusively. The Panhandle region has the lowest proportion of their acres under pure CST among all regions; only 4 percent of the acres were under CST exclusively. Producers in the East region reported the lowest proportion of acres seeded to wheat under CST exclusively.

The highest proportion of acres planted to annual crops using CST exclusively is in the East region with 14 percent of the total acres; respectively 13 percent and 12 percent of the acres planted in Southwest and West Central regions were used under pure

CST. The highest proportion of acres seeded to wheat using IT exclusively is in the West Central and North Central regions.

The average wheat acres for GO purpose is the lowest in the Central region. The South Central region reported the lowest proportions of their wheat acres under GO (ten percent) and DP (34 percent) and also the highest proportion under FO (56 percent) across all regions. In the West Central, Southwest, and Panhandle regions the proportions of FO wheat acres were the lowest.

The average acres rented in the Panhandle region is the greatest across all regions followed by the North Central and West Southwest regions. Only in these three regions the average acres rented and as a result the proportions of acres rented to produce annual crops were greater than the overall survey average acres rented.

REFERENCES

Al-Kaisi, M. and M. Licht. 2004. "Effect of strip-tillage on corn nitrogen uptake and residual soil nitrate accumulation compared with no-tillage and chisel plow". *Agronomy Journal* 96:1164-1171.

Barry, Peter J., and C. B. Baker.1977. "Management of Firm Level Financial Structure". *Agr. Finan. Rev*37:50-63.

Belknap, John, and William E. Saupe. 1988. "Farm Family Resources and the Adoption of No-Plow Tillage in Southwestern Wisconsin." *North Central Journal of Agricultural Economics* 10-1:13-23.

CTIC, Conservation Technology Information Center. 2004. "National survey of conservation tillage practices". [Online]. Available at http://www.conservationinformation.org/ (verified 23 July 2008). CTIC, West Lafayette, IN.

CTIC, Conservation Technology Information Center. 2006. Crop Residue Management Survey. [Online]. Available at http://74.125.95.132/search?q=cache:7HcH-nEqnRMJ:www.conservationinformation.org/pdf/2006CRMSurveySummaryLoRes.pdf+CTIC+Crop+Residue+Management+Survey+2006&cd=2&hl=en&ct=clnk&gl=us CTIC, West Lafayette, IN.

D'Emden, Francis H., Rick S. Llewellyn and Michael P. Burton. 2007. "Adoption of Conservation Tillage in Australian Cropping Regions: An Application of Duration Analysis".

D'Emden, Francis H., Rick S. Llewellyn and Michael P. Burton. 2007. "Adoption of Conservation Tillage in Australian Cropping Regions: An Application of Duration Analysis".

Daniel, H.A., M.B. Cox, and H.M. Elwell. 1956. "Stubble mulch and other cultural practices for moisture conservation and wheat production at the Wheatland Conservation Experiment Station, Cherokee, Okla., 1942-1951". *Production Research Report No. 6, Agricultural Research Service, USDA.*

Davidson, J.M. and P.W. Santelmann. 1973. "An evaluation of various tillage systems for wheat". *Bulletin B-711 Okla. Agr. Exp. Sta., Stillwater*.

Decker, JonAnn E., Francis M. Epplin, Deena L. Morley, and Thomas F. Peeper. 2009. "Economics of Five Wheat Production Systems with No-Till and Conventional Tillage." *Agronomy Journal* forthcoming.

Decker, JonAnn, Francis M.Epplin, Deena L.Orley, and Thomas F.Peepe. 2008. "Alternative Cropping Systems for Traditional Monoculture Tillage". *Paper presented Southern Economics Association annual meeting, Dallas, TX, 2-6 February.*

Epplin, F.M, G.A. Al-Sakkaf, and T.F. Peeper. 1994. "Effects of alternative tillage methods for continuous wheat on grain yield and economics: Implications for conservation compliance". *Journal of Soil and Water Conservation* 49:394-399.

Epplin, Francis M. and Ghazi A. Al-Sakkaf. 1995. "Risk-efficient Tillage Systems and Program Participation Strategies for Land Subject to Conservation Compliance." *Review of Agricultural Economics* 17-3:275-285.

Epplin, Francis M. and Thomas F. Tice. 1986. "Influence of Crop and Farm Size on Adoption of Conservation Tillage." *Journal of Soil and Water Conservation* 41:424 427.

Epplin, Francis M., Curtis J. Stock, Darrel D. Kletke, and Thomas F. Peeper. 2005. "Cost of Conventional Tillage and No-Till Continuous Wheat Production for Four Farm Sizes." *Journal of the American Society of Farm Managers and Rural Appraisers* 68:69-76.

Erenstein, Olaf, and Pedro Cadena Iñiguez. 1997. "The Adoption of Conservation Tillage in a Hillside Maize Production System in Motozintla, Chiapas". *NRG Paper 97-01. Mexico, D.F.: CIMMYT.*

Erenstein, Olaf, and Pedro Cadena Iñiguez. 1997. "The Adoption of Conservation Tillage in a Hillside Maize Production System in Motozintla, Chiapas". *NRG Paper 97-01. Mexico, D.F.: CIMMYT.*

Ervin, Christine A., and David E. Ervin. 1982. "Factors Affecting the Use of Soil Conservation Practices: Hypotheses, Evidence, and Policy Implications." *Land Economics* 58- 3: 277-292.

Ervin, Christine A., and David E. Ervin. Aug., 1982. "Factors Affecting the Use of Soil Conservation Practices: Hypotheses, Evidence, and Policy Implications". *Land Economics* 58: 277-292.

Fenster, C. R, N. P. Woodruff,W. S. Chepil, **a**nd F. H. Siddow**a**y. 1965. "Performance of Tillage Implements in a Stubble Mulch System: III. Effects of Tillage Sequences on Residues, Soil Cloddiness, Weed Control, and Wheat Yield". *Agronomy Journal* 57: 45-490.

Fernandez-Cornejo, Jorge, Stan Daberkow, and William D. McBride.2001. "Decomposing the Size Effect on the Adoption of Innovations: Agrobiotechnology and Precision Agriculture". *AgBioForum* 4:124-136.

Fernandez-Cornejo, Jorge, Stan Daberkow, and William D. McBride.2001. "Decomposing the Size Effect on the Adoption of Innovations: Agrobiotechnology and Precision Agriculture". *AgBioForum* 4: 124-136.

Forcella, Frank and Michael J. Lindstrom. 1981. "Movement and Germination of Weed Seeds in Ridge-Till Crop Production Systems". *Weed Science Society of America and Allen Press* 36:1.

Gould, Brian W., William E. Saupe, and Richard M. Klemme. 1989. "Conservation Tillage: The Role of Farm and Operator Characteristics and the Perception of Soil Erosion." *Land Economics* 65- 2:167-182.

Harper, H.J. 1960. "A 17-year comparison of four methods of tillage for winter wheat in a rotation". *Bulletin B-535 Okla. Agr. Exp. Sta., Stillwater*.

Heer, W.F. and E.G. Krenzer. 1989. "Soil water availability for spring growth of winter wheat (*Triticum aestivum* L.) as influenced by early growth and tillage". *Soil & Tillage Research* 14-2:185-196.

Helms, Gary L., DeeVon Bailey, and Terrence F. Glover. 1987. "Government Programs and Adoption of Conservation Tillage Practices on Nonirrigated Wheat Farms". *American Journal of Agricultural Economics* 69: 786-795.

Iqbal, Muhammad, M. Azeem Khan and Munir Ahmad. 2002. "Adoption of Recommended Varieties: A Farm level Analysis of Wheat Growers in Irrigated Punjab". *Pakistan Institute of Development Economics*.

Iqbal, Muhammad, M. Azeem Khan and Munir Ahmad. 2002. "Adoption of Recommended Varieties: A Farm level Analysis of Wheat Growers in Irrigated Punjab". *Pakistan Institute of Development Economics.*

Krause, Mark A., and J.Roy Black.1995."Optimal Adoption Strategies for No-Till Technology in Michigan". *Review of Agricultural Economics* 17: 299-310.

Lee, Linda K., and William H. Stewart. 1983. "Landownership and the Adoption of Minimum Tillage." *American Journal of Agricultural Economics* 65-2: 256-264.

Lee, Linda K., and William H. Stewart. May., 1983. "Landownership and the Adoption of Minimum Tillage". *American Journal of Agricultural Economics* 65: 256-264.

McFadden, D.1970 "Conditional Logit Analysis of Qualitative Choice Behavior," in Frontiers in Econometrics. Edited by Paul Zaremblea. New York: Academic Press, pp. 105-142.

Oklahoma Agricultural Statistics. OAS. [Online].Available at http://www.nass.usda.gov/ok/Binder1.pdf

Pereira de Herrera, A., and G. Sain. 1999. "Adoption of Maize Conservation Tillage in Azuero, Panama". *CIMMYT Economics Working Paper No. 99-01. Mexico, D.F.: CIMMYT.*

Pereira de Herrera, A., and G. Sain. 1999. "Adoption of Maize Conservation Tillage in Azuero, Panama". *CIMMYT Economics Working Paper No. 99-01. Mexico, D.F.: CIMMYT.*

Rahm, Michael R., and Wallace E. Huffman . 1984. “The Adoption of Reduced Tillage: The Role of Human Capital and Other Variables.” *American Journal of Agricultural Economics* 66-4:405-413.

Rahm, Michael R., and Wallace E. Huffman . 1984. “The Adoption of Reduced Tillage: The Role of Human Capital and Other Variables.” *American Journal of Agricultural Economics* 66-4:405-413.

Rubin, D.B. 1987. “Multiple Imputation for Nonresponse in Surveys”. *New York:John Wiley & Sons, Inc.*

SAS Institute Inc. SAS/STAT User’s Guide, Version 8, Cary, NC: SAS Institute Inc. [Online]. Available at http://support.sas.com/rnd/app/papers/miv802.pdf .The MI Procedure chapter 9.

Schafer, J.L. 1997. “Analysis of Incomplete Multivariate Data” New York*: Chapman and Hall.*

Vyn, Tony J. Strip-Till: A closer Look.[Online]. Available at http://www.agry.purdue.edu/staffbio/Fargo,ND,02-20,2004.pdf

Wu, JunJie, and Bruce A. Babcock. Aug., 1998.“The Choice of Tillage, Rotation, and Soil Testing Practices: Economic and Environmental Implications”. *American Journal of Agricultural Economic*. 80:494-511.

Zingg, A.W., and C.J. Whitfield. 1957. “A summary of research experience with stubble-mulch farming in the western states”. *USDA Technical Bulletin 1166, Washington, D.C.*

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Scope and Method of Study: A survey of 1,703 farms in the State of Oklahoma to determine producers and farms characteristics that affect the use of cultivation methods. The survey is comprised of 27 questions. Seven tillage categories were defined: IT exclusively (producers that use intensive tillage exclusively); CST exclusively (producers that use conservation tillage exclusively); RT exclusively (producers that use reduced tillage exclusively), $IT_{0.5}$ (50 to 99 percent intensive tillage), $CST_{0.5}$ (50 to 99 percent conservation tillage), $RT_{0.5}$ (50 to 99 percent reduced tillage), and OT (other tillage types). Seven regions were considered: the Panhandle region; the West Central region; the Southwest region; the North Central region; the Central region; the South Central region; and the East region.

Findings and Conclusions: IT producers practice more tillage passes on their farms than RT producers which also reported more tillage passes than CST producers. About a quarter of producers reported they seeded wheat for GO purpose, 13 percent for FO, and 64 percent for DP. Two fifths of producers practice a crop rotation system on their farm while three fifth do not practice a crop rotation system. The survey confirms that crop rotations are not common in the state. It is likely that the lack of an economically competitive crop to rotate with winter wheat hinders the use of CST in the state. Alternative winter small grain crops such as oats, barley, and rye are not economically competitive. Summer crops such as corn, soybeans, and grain sorghum do not fit well in a rotation with winter wheat and do not consistently perform well in the climate, which is characterized by hot, dry, windy summers. Compared to IT producers, there is evidence that CST producers rotated their crops more frequently. This will break cycles of weed, disease, and insect pressure by creating a more suitable environment for conservation tillage methods. CST producers operate on larger farm size than IT farmers.

ADVISER'S APPROVAL ______________________________