# AN ECONOMIC COMPARISON OF REDUCED TILLAGE AND NO-TILL CROP PRODUCTION IN WESTERN KANSAS WITH AND WITHOUT OPPORTUNITY CROPPING

by

RAY P. SMITH

B.S., Kansas State University, 1973

---

A THESIS

Submitted in partial fulfillment of the requirements

for the degree

**MASTER OF AGRIBUSINESS**

Department of Agricultural Economics

College of Agriculture

**KANSAS STATE UNIVERSITY**

Manhattan, Kansas

2007

Approved by:

Major Professor
Robert O. Burton Jr.

**ABSTRACT**

This thesis analyses the economics of reduced tillage farming compared to no-till on a western Kansas farm using elevated crop residue levels and higher intensity opportunity cropping strategies to overcome obstacles. Farming expenses are from the author's farm. Crop yields and rainfall data come from the Tribune Unit of the KSU-Southwest Research-Extension Center. Price and crop insurance data are from USDA sources on the Internet.

Crop enterprise budgets are used to determine per acre expenses, net revenue, and the risks of high cropping intensity no-till (NT), and reduced tillage (RT), eco-fallow and with and without opportunity cropping. Grain sorghum was added to the NT rotation, the RT opportunity cropping and the NT opportunity cropping to potentially increase revenues and compete against perennial grasses. However, grain sorghum revenues for various reasons did not cover average variable costs.

Results indicate that NT opportunity cropping can be as or more profitable than RT eco-fallow using corn, however risks and expenses are greater. Over the 10-year study, the NT opportunity cropping averaged $3.97 more net revenue than the RT rotation. The NT rotation averaged $5.40 less net revenue than the RT rotation. The RT opportunity cropping averaged $3.83 less net revenue than the RT rotation. The NT opportunity cropping produced the highest net revenue, followed by the RT rotation. The RT opportunity produced the third highest net revenue and the NT rotation produce the lowest net revenue. The RT rotation showed relatively little risk in the ability to recover variable expenses.

These results only apply to this farm and should be extrapolated to other regions only after study and analysis.  This case study is not necessary applicable to other farms.  However, the ideas and analytical techniques may be used to address similar issues on other farms.

This analysis reveals that higher intensity no-till cropping can increase net revenues as long as intensity is decreased when soil moisture at planting is not adequate.  This allows farmers to benefit from increases in soil organic matter and decreases in soil erosion from no-till farming.

# TABLE OF CONTENTS

## LIST OF FIGURES

## LIST OF TABLES

# ACKNOWLEDGMENTS

The author wishes to thank the faculty and staff of the Department Agricultural Economics at Kansas State University and Kansas State University Research and Extension. This is my fourth degree at KSU and my second masters degree from the Department Agricultural Economics and I have grown to respect and rely on the guidance and research available from this organization.

In particular I would like to thank Dr. Burton and his direction in choosing a topic and carrying the project to completion. It was exactly what was needed. I would highly recommend Dr. Burton as major professor for anyone working on a Thesis for the Masters of Agribusiness. Also thank you to Dr. Alan Schlegel, the agronomist-in-charge of the Tribune Unit of the KSU-Southwest Research-Extension Center, who has been invaluable in accumulating and supplying data.

# CHAPTER 1: INTRODUCTION

In recent years reduced tillage has become a popular farming method increasing production and conserving soils. In western Kansas, no-till farming offers benefits of increased yields and less erosion compared to reduced tillage, however, technical problems have discouraged adoption of no-till. The purpose of this thesis is to compare the economics of reduced tillage farming to no-till in western Kansas using elevated crop residue levels and higher intensity opportunity cropping strategies to overcome obstacles.

## 1.1 Potential of No-Till in Semi-arid Western Kansas

The benefits of no-till farming and the decrease in the cost of glyphosate herbicide have caused no-till farming to increase in popularity. In semi-arid western Kansas, Schlegel, Dumler, and Thompson have shown a 23% increase in grain sorghum (milo) yields using no-till methods over reduced tillage in a wheat-grain sorghum-summer fallow rotation. A 90% gain in grain sorghum yields occurred during the 2001 to 2004 drought. No-till tends to increase yields with time and provide higher yields when moisture is limited. Schlegel, Stone, Dumler, and Thompson also showed that the water infiltration rates were 50% greater with no-till over reduced tillage, conventional-tillage, and undisturbed sod. No-till farming increases soil organic matter and maintains a surface residue cover that protects the soil from wind and water erosion.

## 1.2 Problem Statement

Three barriers are holding back the adoption of no-till in far western Kansas. First, some native perennial grasses are resistant to herbicides. Second, dryness in September can result in a soil crust forming that seeding equipment will not penetrate for fall planting.

Third, current no-till seeding technology runs over residue, breaking it off at ground level. This crop residue decomposes quicker and is removed by rain and wind, exposing soils to erosion.

Currently, eco-fallow and reduced tillage are popular farming methods. Eco-fallow is a crop rotation which lasts for three years. The first year the land is summer fallowed and wheat is planted in the fall. Wheat is harvested in mid-summer of the second year. A summer crop, such as corn, grain sorghum, or sunflowers is planted in May or June and harvested in the fall of the third year. If tillage is used only during the summer fallow period the practice is called reduced tillage. Reduced tillage is common in western Kansas and is replacing conventional-tillage in which tillage is used in all years.

Tillage is used to increase the chances that moisture will be available to sprout wheat in the fall. Tillage kills the weeds including native perennial grasses and provides a compacted layer to seal in subsoil moisture in case rains are not received in September. When wheat is planted, the hoe drill moves several inches of soil, placing the seed into the compacted-layer-subsoil-moisture and leaves the soil in ridges that helps protect against wind erosion in the spring.

During long periods of drought, moisture will not be available for adequate seedbeds. Farmers plant wheat anyway hoping that later rains may sprout the wheat. The drill also forms ridges that protect the land from wind erosion. Once the land has been tilled during summer fallow, the farmer has little choice but to drill the wheat in the fall because the soil protecting residue has been destroyed. During the winter, moisture with repeated freezing and thawing softens the soil and produces a dusty layer that can blow.

Winter also cools the soil which allows seedbeds to retain winter and spring moisture for longer periods of time. These wetter seedbeds are available in early May, before temperatures rise in late May and early June. Any standing residue protects the soil from wind erosion and consequently extends the time the ground is cool and wet.

Glyphosate herbicide is popular because of its ability to kill a large spectrum of weeds and its relative safety. The glyphosate warning labels carry the lowest level assigned by the Environmental Protection Agency. Glyphosate can be used during fallow and in crops which are genetically modified for its use. Glyphosate is a photosynthesis inhibitor. As long as it can penetrate the outer surface of a plant it can usually kill the plant unless the plant can metabolize the glyphosate, such as in genetically modified crops. Glyphosate binds tightly to soil particles and cannot be trans-located to the plant. In order for glyphosate to work, it must be applied to the foliage of the plant. It poses little risk of entering water supplies. Once attached to the soil it is metabolized by soil microbes and changed into water and carbon dioxide.

No-till farming uses alternative methods, other than tillage, such as sanitation, competition, and rotations to control weeds. Sanitation requires keeping weed seeds out of the seedbed. No-till farmers must prevent the weeds from producing seed and use low soil disturbance planters that do not incorporate the weed seed into the soil. Because no-till farming increases moisture availability, weeds have more opportunity to flourish. Farmers must replace fallow with crops and utilize higher water-use crop rotations to provide competition for the weeds. Rotation of crops allows using different herbicides while the crop is growing and fallow during different times of the year when weeds can be easily and cheaply controlled. Crop canopies also shade weeds from sunlight. This strategy is accomplished by planting higher seeding rates in narrow rows. Maintaining crop residues also provides shading effects.

Successfully planting a crop without tillage into the previous crop's residue is essential to no-tilling. Seeding equipment is divided into two classes: planters and drills. Planters use round disks to cut a seed slot. Drills can use disks or hoe openers, but only disks provide low soil disturbance. Planters "singulate" by measuring each single seed. Planters work well for large seeded crops that require smaller numbers of seeds per acre. Grain sorghum, corn and sunflowers are typically planted in 30-inch row spacing. Drills measure seed volumetrically and tend to have more rows per foot of implement than planters. A typical row width for drills in western Kansas is 12 inches. Many no-till drills have row spacing as close as 7½ inches. Drills are used for wheat and grain sorghum. The goal of narrow row spacing is for the crop to quickly canopy; however, narrow row spacing destroys more crop residue.

### 1.3 Low Residue Disturbance Seeding

Hagney states that because crop residues increase water infiltration and crop yields are largely determined by water availability, therefore maintaining crop residue is important. Seeding is one of the areas Hagney feels needs to be adjusted to increase crop residues. He recommends low disturbance disk openers with narrow gauge wheels. Row spacing should be considered so that no more row openers are run than necessary to reduce residue loss.

Auto-steer guidance allows precision farming and the ability to control seed placement to minimize disturbance of residue. Each new crop can be planted between the "old rows" allowing more of the previous crop's residue to remain standing, attached, and undisturbed. The previous crop's residues act as a cover against rain and wind and a canopy to shade weeds.

Native perennial grasses can be overcome with three agronomic strategies. First grain sorghum will be planted in 15-inch rows to canopy and shade native perennial grasses. Grain sorghum provides excellent canopy and leaves large amounts of standing residue. Corn is usually planted in 30-inch rows because most corn headers used for harvesting require 30-inch rows. Corn has low seeding rates and narrow rows do not improve the canopy. Secondly, more intensive cropping with less fallow time and more opportunity cropping decreases moisture availability to perennial grasses. Lastly, recommended rates of glyphosate herbicide used at appropriate times will also give better control of perennial grasses than lower rates used to reduce costs.

This system will not be a controlled traffic system because the majority of the traffic will not follow the same path in the field every year. When planting 30-inch rows, the planting swath is 15-inches wider than when planting 15-inch rows because the planter moves over 30 inches to make the next pass. When planting 15-inch rows, the planter moves over 15 inches. The planters may start on the same path, but will follow different traffic patterns through the rest of the field.  This, coupled with the planter moving over 7½ inches to keep the previous crops residue intact, will spread out traffic patterns.  Harvest traffic will not be controlled resulting in some residue disturbance.  Hagny states that controlled traffic is not a good idea because heavy traffic areas lose water infiltration and erode during heavy rainfall.

Increased residue levels should reduce the baking of soils from the sun and wind during the summer fallow period and increase the chances of having adequate soil moisture in the seedbed when seeding wheat in the fall.  Currently, using no-till, the author believes that sometimes as little as three tenths of an inch of rainfall in the month of September will allow seeding.  However, some years, even this amount will not be received, and wheat stands will be poor.  When moisture for adequate seedbeds is not available, fields may have to remain fallow until the next spring.

### 1.4 Opportunity Cropping

Crop prices, input costs, and weather variability, especially rain, can affect crop choices making rotations impractical.  Opportunity cropping uses subsoil moisture levels, crop prices, input costs, residue levels at planting time, amount of crop residue produced by the chosen crop, and topsoil moisture levels to determine if fields will be planted and what crops will be planted.  Increased residue levels will allow more intensive cropping because of increased soil moisture and higher residue levels will allow more fallow during drought because the farmer does not need to plant to replace soil cover destroyed by tillage.  The overwhelming factor for opportunity cropping in semi-arid regions is rainfall.  Prices can change from the time the farmer decides to plant the crop until the crop is harvested.  Also, the crop can be stored and marketed after harvest. Input prices do not usually vary greatly from year to year.

## 1.5 Location of Research

The farm used in this study is located in Greeley County in western Kansas on the Kansas-Colorado border. The Southwest Research-Extension Center, Tribune Unit is located in Greeley County and will be a major source for weather and yield data. Expense data are the actual expenses of the author's farm located in Greeley County. All field operations are done by custom farmers and are paid on a per acre basis. The custom planter currently has a 15-inch planter for planting narrow row sorghum.

## 1.6 Literature Review

In this section the current literature is reviewed to gain insight into current research on no-till farming. The literature review section is broken into five sections. Section 1.6.1 discusses economic support for more intensive cropping. Section 1.6.2 discusses importance of wheat in no-till. Section 1.6.3 discusses the yield benefits of crop residue. Section 1.6.4 discusses support for crop sequencing. Section 1.6.5 discusses dry land water management.

### *1.6.1 Economic Support for More Intensive Cropping*

Smith and Young indicate that summer fallow acres in the U.S. decreased by 43% from 1964 to 1997. Dhuyvetter, Thompson, Norwood, and Halverson showed that more intensive cropping systems had higher costs per acre but were more profitable and less risky. Furthermore, these systems can improve fallow efficiency and reduce soil erosion. Schlegel, Dumler, and Thompson determined that a Wheat-Sorghum-Sorghum-Fallow rotation was slightly more profitable than the less intensive Wheat-Sorghum-Fallow rotation in western Kansas indicating that rotations longer than eco-fallow are economical. Schlegel, Stone, Dumler, and Thompson found that no-till yields increase with time and are much higher in dry years. Farahani and Peterson state that cropping intensity per year increases when moving from a 2-year to a 3-or 4-year rotation, but annualized non-crop (fallow) duration does not decrease and actually increases slightly. This occurs because summer crops have a shorter growing cycle than wheat. Because 65% of annual rainfall falls during the summer months, summer crops increase water-use efficiency by increasing the likelihood of making grain out of the rain rather than allowing it to evaporate. Stone and Schlegel found that the yield per inch of water for wheat increases from 3.2 bushels/inch for conventional tillage to 5.2 bushel/inch for no-till. Grain sorghum water-use efficiency increased from 5.2 bushels/inch for reduced tillage to 7.5 bushel/inch for no-till. Dhuyvetter and Kastens reported that the Northwest Kansas Farm Management Association data for more than 10 years showed a 15% yield increase for no-till corn over conventional and reduced tillage corn and a 22% yield increase for no-till grain sorghum over conventional and reduced tillage grain sorghum. The grain sorghum results were very similar to Schlegel, Dumler, and Thompson's results.

*1.6.2 Importance of Wheat in No-Till*

Schlegel, Dhuyvetter, Thompson, and Havlin found that tillage had little impact on wheat yields but no-till increased sorghum yields by 23% over reduced tillage. Lyon, Baltensperger, Blumethal, Burgener, and Harvenson showed that wheat planted into corn stubble was much less profitable than summer fallow wheat. However oat and pea forage/wheat used in a continuous cropping system was more profitable than summer fallow wheat, indicating that it is possible to find profitable rotations with no summer fallow. In this study, increased cropping intensity lowered the yield of the wheat, but the profitability of the cropping system was increased.

*1.6.3 Yield Benefits of Crop Residue*

Power, Doran, Koerner, and Whilhelm found that increasing crop residue had a residual impact on yields that lasted for many years. The test plots had residue cover manually increased by 50% during the initial 6-year study while other plots were left unchanged. During the 8-year follow-up study in which residue was no longer changed, an average 11% yield improvement occurred over the unchanged residue plots.

Power, Whilhelm, and Doran found that corn yield in Eastern Nebraska increased at a rate of 12% of the mass of the residue left after harvest of the previous crop. Soybean yields increased at a rate of 9%. They concluded that maintaining crop residue is an excellent management tool for reducing the impact of stressful climate. Increasing crop residue also decreased maximum soil temperature by at least 5 degrees Celsius.

*1.6.4 Support for Crop Sequencing*

Anderson noted that winter wheat yields 13% more if grown once in a four-year rotation. Corn yields are reduced 21% when planted into grain sorghum stalks. This yield loss is due to allopathic effects and nitrogen immobilization of the sorghum residue. Anderson also reported a synergistic affect of planting corn into wheat stubble but no effect of planting grain sorghum into corn stalks.

*1.6.5 Dry Land Water Management*

Lyon showed that yields of high water use crop such as corn and grain sorghum are not related to soil moisture at planting. Soil water at planting can be negatively correlated to yield. Westfall showed that 70% of the yield of dry land corn in semi-arid eastern Colorado can be related to the rainfall for July 15$^{th}$ to August 25$^{th}$.

**1.7 Conceptual Issues**

Economics defines the short run as a time period in which some inputs are fixed. Fixed costs are not under the control of the manager in the short run. Short run costs are the only costs that need to be considered because the manager needs to know the marginal changes that will result from a change in the controllable factors. The only cost and incomes that will need to be analyzed are the costs and incomes that are changed as a result of the change in farming practice. Costs associated with land and management are the same for all cropping systems and are not considered. Recommended amounts of inputs will be used. Direct payments and counter cyclical payments are fixed, and are not included in the study. This study attempts to determine which rotation should be used for one hypothetical field based on historical yields and current input costs. The goal is to find the optimum rotation and a mixture of rotations will not be considered. The purpose of this thesis is to determine which farming practices produce the highest net revenue with acceptable costs and risks for a dry land farm in western Kansas. Enterprise budgeting will be used to answer the question.

The concept of opportunity cost applies because there is a return foregone to tillage in the form of reduced organic matter and increased soil erosion. This cost is difficult to quantify and for this analysis it will be assumed that if the return of the two systems is equal then no-till will be better because of opportunity costs associated with tillage.

### 1.8 Objective

The objective of this thesis is to compare per acre expenses, net revenue, and the risks of high cropping intensity no-till (NT) with reduced tillage (RT) eco-fallow with and without opportunity cropping. At the same level of net revenue per acre, NT farming will be chosen to replace RT because of the improved erosion control.

### 1.9 Questions to be Answered

How do the cost of production, net revenue, and risk compare between:

1. RT eco-fallow and high-intensity-low-residue-disturbance NT cropping? (How does wheat\corn\summer fallow RT compare to wheat\corn\grain sorghum\summer fallow NT?)

2. RT opportunity cropping and NT opportunity cropping? (How does opportunity cropping with wheat, corn, grain sorghum, and tilled fallow compare to opportunity cropping with wheat, corn, grain sorghum, and NT fallow?)

3. RT eco-fallow and RT opportunity cropping? (How does wheat\corn\summer fallow RT compare to opportunity cropping with wheat, corn, grain sorghum, and tilled fallow?)

4. High-intensity-low-residue-disturbance NT cropping and NT opportunity cropping? (How does wheat\corn\grain sorghum\summer fallow compare to opportunity cropping with wheat, corn, grain sorghum, and NT fallow?)

Table 1.1 shows the scenarios to be compared in a two by two grid. Opportunity cropping is discussed more thoroughly in section 2.4.

**Table 1.1 Cropping System Grid**

| | Set rotation | Opportunity Cropping |
|---|---|---|
| Reduced tillage | Wheat/corn/summer fallow | With wheat, corn, grain sorghum, and tilled fallow. |
| No-Till | Wheat/corn/grain sorghum/summer fallow | With wheat, corn, grain sorghum, and NT fallow. |

# CHAPTER 2: PROCEDURE AND DATA

Crop enterprise budgets are used to determine net revenue, cost of production, and risk for each scenario and for each crop in each scenario. The study uses as many years of NT yield data as available from Tribune Unit of the KSU-Southwest Research-Extension Center. For the wheat-corn-RT fallow rotation the beginning farm is 1/3 wheat, 1/3 corn, and 1/3 RT fallow.  The opportunity cropping RT and both NT rotations will have four beginning equal sized fields of wheat, corn, grain sorghum, and summer fallow.  The costs of production and net revenue for each cropping system are compared by calculating a per acre average.

Net revenue is also calculated for each crop in each system.  All summer fallow expenses are charged to the following crop.  Summer fallow may improve all yields in the rotation but it is beyond the scope of this paper to estimate the percentages.  Secondly, this paper is focused on determining the most economical system and not the most profitable crop.  A single crop or fallow can show little or no profitability but if it improves the profitability of the rotation, it should be included.

## 2.1 Net Revenue

A budget is prepared for each crop for each year for each cropping system to take into account yearly variations such as dry years when there is no harvest.  Incomes and costs only include those that are affected by the change in farming practice.  Direct and counter-cyclical payments, land costs, and management costs are not included.  If fields do not produce enough revenue to cover the cost of harvest, the field is not harvested.  There is no harvest expense and no grain income in these years

The yield data (Table 2.1) and the price data (Table 2.2) are historical with yield and price data from corresponding years. Crop Price data are from Kansas Agricultural Statistics West Central District. The price is the average of the first 6 months after harvest. Various yield data for RT and NT summer fallow wheat, corn, and grain sorghum after corn and rainfall data (Table 2.3) are from the Southwest Research-Extension Center, Tribune Unit. Since yield data comparing RT to NT corn are not available for western Kansas some data must be estimated. From Dhuyvetter and Kastens it is estimated that NT corn yields 15% more than RT corn. Schlegel, Dumler, and Thompson showed that NT grain sorghum yields 23% more than RT grain sorghum. If yield data are not available, yields are estimated using water use efficiency data. Opportunity cropped wheat is estimated with Stone and Schlegel's water use equation $Y = -3793 + 137.65X$. X is the water supply, the total sum of soil water at emergence and in-season precipitation in cm. Y is the yield in kilograms per hectare. Stone and Schlegel's water use equation for grain sorghum, $Y = -2889 + 184.617X$, is used to estimate NT fallow grain sorghum but produced yields lower than grain sorghum after wheat in some cases. In those cases, I used the grain sorghum yield after wheat from the Southwest Research-Extension Center, Tribune Unit.

**Table 2.1 Yield Data (bushel per acre)**

| Reduced tillage rotation | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|---|---|---|
| Wheat | 25a | 42a | 68a | 77a | 32a | 40a | 0a | 15a | 2a | 32a |
| Corn | 80a | 33a | 78a | 70a | 10b | 4b | 0b | 4b | 105b | 15b |

| Reduced tillage opportunity | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|---|---|---|
| Wheat | 25a | 42a | 68a | 77a | 32a | 40a | 0a | 15a | 2a | 32a |
| Corn | 80a | 33a | 78a | 70a | 10a | 4b | 0b | 4b | 105b | 15b |
| Grain Sorghum | 28b | 37b | 81b | 60b | 19b | 20b | 0b | 7b | 38b | 50b |

| No-till rotation | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|---|---|---|
| Wheat | 26a | 57a | 70a | 74a | 46a | 40a | 0a | 28a | 3a | 33a |
| Corn | 92b | 38b | 90b | 81b | 11a | 5a | 0a | 5a | 121a | 17a |
| Grain Sorghum | 35a | 45a | 100a | 74a | 23a | 24a | 0a | 8a | 47a | 62a |

| No-till opportunity | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|---|---|---|
| Wheat | 26a | 57a | 70a | 74a | 46a | 40a | 0a | 28a | 3a | 33a |
| Opportunity wheat | | | | | | | | | | 8c |
| Corn | 92b | 38b | 90b | 81b | 11a | 5a | 0a | 5a | 121a | 17a |
| Grain Sorghum | 35a | 45a | 100a | 74a | 23a | 24a | 0a | 8a | 47a | 62a |
| Fallow Grain Sorghum | | | | | | 73d | 12.7e | | | |

a These data were obtained from Alan Schlegel, the agronomist-in-charge of the Tribune Unit, Southwest Research-Extension Center of Kansas State University. The yields are a compilation of several different RT and NT studies performed at the Tribune center.

b Denotes an estimated number. NT grain sorghum yields are 23% higher than NT yields. NT corn yields are 15% higher than RT yields.

c This yield was estimated using Stone and Schlegel's water use equation Y = -3793 + 137.65X where X is the water supply, the total sum of soil water at emergence and in-season precipitation in cm. Y is the yield in kg/ha. Soil water at emergence was assumed to be 43% of the precipitation from August 25$^{th}$ to October 15$^{th}$ of 2004. In season precipitation was 11.05 inches from October 15$^{th}$ to June 15$^{th}$ of 2005.

d This summer fallow grain sorghum yield has been changed to the highest grain sorghum yield obtained in the studies, because equation predictions were low for 2001. The equation predicted 44.6 bushels per acre. The equation should have predicted a larger yield because the fallow period was longer for the summer fallow grain sorghum than for the grain sorghum following wheat.

e This yield was estimated using Stone and Schlegel's water use equation Y = -2889 + 184.17X where X is the water supply, the total sum of soil water at emergence and in-season precipitation in cm. Y is the yield in kg/ha. Soil water at emergence was assumed to be 43% of the precipitation from August 25$^{th}$ to October 15$^{th}$ of 2004. In season precipitation was 11.05 inches from October 15$^{th}$ to June 15$^{th}$ of 2005.

**Table 2.2 Price Data**

| | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wheat | $3.42 | $4.65 | $4.34 | $3.21 | $2.53 | $2.21 | $2.68 | $2.64 | $ 3.89 | $3.37 | $3.13 | $3.29 |
| Corn | | $3.33 | $2.69 | $2.53 | $1.95 | $1.81 | $2.07 | $2.03 | $ 2.53 | $2.66 | $2.12 | $2.12 |
| Sorghum | | $3.64 | $2.36 | $2.31 | $1.70 | $1.65 | $1.90 | $1.87 | $ 2.47 | $2.71 | $1.76 | $1.84 |

Crop Price data are from Kansas Agricultural Statistics West Central District.
Wheat- Average of 6 month marketing year Jul-Dec
Corn- Average of 6 month marketing year Oct-Mar
Grain Sorghum- Average of 6 month marketing year Nov-Apr

**Table 2.3 Rainfall Data (inches) (only relevant data is included)**

| | June 16th - May 1st | Sep 16 - May 1 | Sep 16 - Oct 15 | Aug 25 - Oct 15 | Oct. 15th - June 15th |
|---|---|---|---|---|---|
| 1995 | | | 0.48 | 0.97 | |
| 1996 | 8.97 | 2.33 | 2.1 | 4.14 | |
| 1997 | 18.06 | 4.98 | 2.38 | 2.63 | |
| 1998 | 22.46 | 10.32 | 0.42 | 1.51 | |
| 1999 | 17.08 | 8.4 | 2.25 | 3 | |
| 2000 | 16.28 | 6.91 | 0.38 | 0.77 | |
| 2001 | 12.4 | 7.69 | 0.29 | 0.74 | |
| 2002 | 7.43 | 1.64 | 1.71 | 3.87 | |
| 2003 | 11.04 | 7.29 | 0.05 | 1.54 | |
| 2004 | 12.84 | 6.12 | 3.07 | 3.11 | |
| 2005 | 17.4 | 8.79 | 2.46 | 2.81 | 11.05 |

The yield data are also used as rate yields for indemnity payments (Table 2.4 and 2.5). Insurance rates are determined by the rate yield. Sixty percent of County T-yields are substituted for rate yields when yields fall below this level to determine the proven yield. The proven yield is the 10-year average of sixty percent of County T-yields and actual yields whichever is higher. County T-yields are county averages used by the Risk Management Agency (RMA). The county T-yields were obtained from a local crop insurance agent (Farr). The proven yields do not change during the study because NT yields are not available before the study time frame. The cost of insurance or premium is determined using the United States Department of Agriculture (USDA) RMA premium calculator available on the Internet (USDA). The insurance premium is calculated by multiplying the planting price times the proven yield times insurance rate times the insurance level. The author uses an insurance level of 70%. The insurance rate is determined using the RMA premium calculator. The insurance rate is the insurance premium divided by the guarantee. Premiums for 2006 were determined using the RMA calculator. The insurance level times the proven yield gives the guarantee yield. The sign up guarantee is the planting price times the proven yield times the insurance level. The harvest guarantee is the harvest price times the proven yield times the insurance level. The insurance level is 70 percent, the same as used on the author's farm. Crop Revenue Coverage (CRC) crop insurance indemnity payments are calculated whenever revenue falls below the guarantee. Crop insurance indemnity payments are equal to the actual yield times the harvest price subtracted from the greater of the harvest price or planting price times the guarantee. If revenues are greater than the highest guarantee, no indemnity payment is received. Insurance planting prices and harvest prices are obtained from Agmanager.Com (Barnaby). Separate proven yields are maintained for summer fallow wheat and wheat with no summer fallow. Because opportunity wheat is only planted once, the proven yield is equal to County T-yields. Separate proven yields are not calculated for summer fallow grain sorghum.

## Table 2.4 RT Indemnity Payments

| **Wheat** | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|---|---|---|
| Rate Yield | 25.0 | 42.0 | 68.0 | 77.0 | 32.0 | 40.0 | 0.0 | 15.0 | 2.0 | 32.0 |
| Proven yield calc. | 25.0 | 42.0 | 68.0 | 77.0 | 32.0 | 40.0 | 19.8 | 19.8 | 19.8 | 32.0 |
| Planting Price | $ 3.91 | $ 4.13 | $ 3.95 | $ 3.16 | $ 3.34 | $ 3.31 | $ 3.34 | $ 3.73 | $ 3.40 | $ 3.56 |
| Harvest Price | $ 5.76 | $ 3.64 | $ 3.04 | $ 2.84 | $ 3.02 | $ 3.07 | $ 3.09 | $ 3.14 | $ 3.77 | $ 3.28 |
| Proven yield | 37.5 | 37.5 | 37.5 | 37.5 | 37.5 | 37.5 | 37.5 | 37.5 | 37.5 | 37.5 |
| Guarantee yield | 26.3 | 26.3 | 26.3 | 26.3 | 26.3 | 26.3 | 26.3 | 26.3 | 26.3 | 26.3 |
| Sign Up Guarantee | $ 102.75 | $ 108.53 | $ 103.80 | $ 83.04 | $ 87.77 | $ 86.98 | $ 87.77 | $ 98.02 | $ 89.35 | $ 93.55 |
| Harvest Guarantee | $ 151.36 | $ 95.65 | $ 79.89 | $ 74.63 | $ 79.36 | $ 80.67 | $ 81.20 | $ 82.51 | $ 99.07 | $ 86.19 |
| Revenue | $ 144.00 | $ 152.88 | $ 206.72 | $ 218.68 | $ 96.64 | $ 122.80 | $ - | $ 47.10 | $ 7.54 | $ 104.96 |
| Indemnity | $ 7.36 | $ - | $ - | $ - | $ - | $ - | $ 87.77 | $ 50.92 | $ 91.53 | $ - |
| **Corn** | | | | | | | | | | |
| Rate Yield | 80.0 | 33.0 | 78.0 | 70.0 | 9.6 | 4.3 | 0.0 | 4.3 | 105.2 | 14.8 |
| Proven yield calc. | 80.0 | 33.6 | 78.0 | 70.0 | 33.6 | 33.6 | 33.6 | 33.6 | 105.2 | 33.6 |
| Planting Price | $ 3.08 | $ 2.73 | $ 2.84 | $ 2.40 | $ 2.51 | $ 2.46 | $ 2.32 | $ 2.42 | $ 2.83 | $ 2.32 |
| Harvest Price | $ 2.68 | $ 2.76 | $ 2.19 | $ 1.96 | $ 2.11 | $ 2.05 | $ 2.43 | $ 2.37 | $ 1.99 | $ 1.93 |
| Proven yield | 53.5 | 53.5 | 53.5 | 53.5 | 53.5 | 53.5 | 53.5 | 53.5 | 53.5 | 53.5 |
| Guarantee yield | 37.4 | 37.4 | 37.4 | 37.4 | 37.4 | 37.4 | 37.4 | 37.4 | 37.4 | 37.4 |
| Sign Up Guarantee | $ 115.31 | $ 102.20 | $ 106.32 | $ 89.85 | $ 93.97 | $ 92.10 | $ 86.85 | $ 90.60 | $ 105.95 | $ 86.85 |
| Harvest Guarantee | $ 100.33 | $ 103.33 | $ 81.99 | $ 73.38 | $ 78.99 | $ 76.75 | $ 90.97 | $ 88.73 | $ 74.50 | $ 72.25 |
| Revenue | $ 214.40 | $ 91.08 | $ 170.82 | $ 137.20 | $ 20.18 | $ 8.91 | $ - | $ 10.30 | $ 209.38 | $ 28.53 |
| Indemnity | $ - | $ 12.25 | $ - | $ - | $ 73.78 | $ 83.18 | $ 90.97 | $ 80.29 | $ - | $ 58.32 |
| **Grain Sorghum** | | | | | | | | | | |
| Rate Yield | 28.5 | 36.6 | 81.3 | 60.2 | 18.7 | 19.5 | 0.0 | 6.5 | 38.2 | 50.4 |
| Proven yield calc. | 30.0 | 36.6 | 81.3 | 60.2 | 30.0 | 30.0 | 30.0 | 30.0 | 38.2 | 50.4 |
| Planting Price | $ 2.93 | $ 2.59 | $ 2.70 | $ 2.29 | $ 2.38 | $ 2.34 | $ 2.20 | $ 2.30 | $ 2.71 | $ 2.15 |
| Harvest Price | $ 2.70 | $ 2.67 | $ 2.08 | $ 1.91 | $ 2.00 | $ 1.95 | $ 2.39 | $ 2.15 | $ 1.97 | $ 1.87 |
| Proven yield | 41.7 | 41.7 | 41.7 | 41.7 | 41.7 | 41.7 | 41.7 | 41.7 | 41.7 | 41.7 |
| Guarantee yield | 29.2 | 29.2 | 29.2 | 29.2 | 29.2 | 29.2 | 29.2 | 29.2 | 29.2 | 29.2 |
| Sign Up Guarantee | $ 85.46 | $ 75.54 | $ 78.75 | $ 66.79 | $ 69.42 | $ 68.25 | $ 64.17 | $ 67.08 | $ 79.04 | $ 62.71 |
| Harvest Guarantee | $ 78.75 | $ 77.88 | $ 60.67 | $ 55.71 | $ 58.33 | $ 56.88 | $ 69.71 | $ 62.71 | $ 57.46 | $ 54.54 |
| Revenue | $ 76.83 | $ 97.68 | $ 169.11 | $ 114.91 | $ 37.40 | $ 38.05 | $ - | $ 13.98 | $ 75.28 | $ 94.26 |
| Indemnity | $ 8.63 | $ - | $ - | $ - | $ 32.02 | $ 30.20 | $ 69.71 | $ 53.10 | $ 3.77 | $ - |

## Table 2.5 NT Indemnity Payments

| Wheat | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|---|---|---|
| Rate Yield | 26.0 | 57.0 | 70.0 | 74.0 | 46.0 | 40.0 | 0.0 | 28.0 | 3.0 | 33.0 |
| Proven yield calc. | 26.0 | 57.0 | 70.0 | 74.0 | 46.0 | 40.0 | 19.8 | 28.0 | 19.8 | 33.0 |
| Planting Price | $ 3.91 | $ 4.13 | $ 3.95 | $ 3.16 | $ 3.34 | $ 3.31 | $ 3.34 | $ 3.73 | $ 3.40 | $ 3.56 |
| Harvest Price | $ 5.76 | $ 3.64 | $ 3.04 | $ 2.84 | $ 3.02 | $ 3.07 | $ 3.09 | $ 3.14 | $ 3.77 | $ 3.28 |
| Proven yield | 41.4 | 41.4 | 41.4 | 41.4 | 41.4 | 41.4 | 41.4 | 41.4 | 41.4 | 41.4 |
| Guarantee yield | 29.0 | 29.0 | 29.0 | 29.0 | 29.0 | 29.0 | 29.0 | 29.0 | 29.0 | 29.0 |
| Sign Up Guarantee | $ 113.20 | $ 119.57 | $ 114.36 | $ 91.49 | $ 96.70 | $ 95.83 | $ 96.70 | $ 107.99 | $ 98.44 | $ 103.07 |
| Harvest Guarantee | $ 166.76 | $ 105.39 | $ 88.01 | $ 82.22 | $ 87.44 | $ 88.88 | $ 89.46 | $ 90.91 | $ 109.15 | $ 94.96 |
| Revenue | $ 149.76 | $ 207.48 | $ 212.80 | $ 210.16 | $ 138.92 | $ 122.80 | $ - | $ 87.92 | $ 11.31 | $ 108.24 |
| Indemnity | $ 17.00 | $ - | $ - | $ - | $ - | $ - | $ 96.70 | $ 20.07 | $ 97.84 | $ - |
| **Corn** | | | | | | | | | | |
| Rate Yield | 92.0 | 38.0 | 89.7 | 80.5 | 11.0 | 5.0 | 0.0 | 5.0 | 121.0 | 17.0 |
| Proven yield calc. | 92.0 | 38.0 | 89.7 | 80.5 | 33.6 | 33.6 | 33.6 | 33.6 | 121.0 | 33.6 |
| Planting Price | $ 3.08 | $ 2.73 | $ 2.84 | $ 2.40 | $ 2.51 | $ 2.46 | $ 2.32 | $ 2.42 | $ 2.83 | $ 2.32 |
| Harvest Price | $ 2.68 | $ 2.76 | $ 2.19 | $ 1.96 | $ 2.11 | $ 2.05 | $ 2.43 | $ 2.37 | $ 1.99 | $ 1.93 |
| Proven yield | 58.9 | 58.9 | 58.9 | 58.9 | 58.9 | 58.9 | 58.9 | 58.9 | 58.9 | 58.9 |
| Guarantee yield | 41.2 | 41.2 | 41.2 | 41.2 | 41.2 | 41.2 | 41.2 | 41.2 | 41.2 | 41.2 |
| Sign Up Guarantee | $ 127.02 | $ 112.59 | $ 117.12 | $ 98.98 | $ 103.51 | $ 101.45 | $ 95.68 | $ 99.80 | $ 116.71 | $ 95.68 |
| Harvest Guarantee | $ 110.52 | $ 113.82 | $ 90.32 | $ 80.83 | $ 87.02 | $ 84.54 | $ 100.21 | $ 97.74 | $ 82.07 | $ 79.59 |
| Revenue | $ 246.56 | $ 104.74 | $ 196.44 | $ 157.78 | $ 23.21 | $ 10.25 | $ - | $ 11.85 | $ 240.79 | $ 32.81 |
| Indemnity | $ - | $ 9.08 | $ - | $ - | $ 80.30 | $ 91.20 | $ 100.21 | $ 87.95 | $ - | $ 62.87 |
| **Grain Sorghum** | | | | | | | | | | |
| Rate Yield | 35.0 | 45.0 | 100.0 | 74.0 | 23.0 | 24.0 | 0.0 | 8.0 | 47.0 | 62.0 |
| Proven yield calc. | 35.0 | 45.0 | 100.0 | 74.0 | 30.0 | 30.0 | 30.0 | 30.0 | 47.0 | 62.0 |
| Planting Price | $ 2.93 | $ 2.59 | $ 2.70 | $ 2.29 | $ 2.38 | $ 2.34 | $ 2.20 | $ 2.30 | $ 2.71 | $ 2.15 |
| Harvest Price | $ 2.70 | $ 2.67 | $ 2.08 | $ 1.91 | $ 2.00 | $ 1.95 | $ 2.39 | $ 2.15 | $ 1.97 | $ 1.87 |
| Proven yield | 48.3 | 48.3 | 48.3 | 48.3 | 48.3 | 48.3 | 48.3 | 48.3 | 48.3 | 48.3 |
| Guarantee yield | 33.8 | 33.8 | 33.8 | 33.8 | 33.8 | 33.8 | 33.8 | 33.8 | 33.8 | 33.8 |
| Sign Up Guarantee | $ 99.06 | $ 87.57 | $ 91.29 | $ 77.42 | $ 80.47 | $ 79.12 | $ 74.38 | $ 77.76 | $ 91.63 | $ 72.69 |
| Harvest Guarantee | $ 91.29 | $ 90.27 | $ 70.32 | $ 64.58 | $ 67.62 | $ 65.93 | $ 80.81 | $ 72.69 | $ 66.61 | $ 63.22 |
| Revenue | $ 94.50 | $ 120.15 | $ 208.00 | $ 141.34 | $ 46.00 | $ 46.80 | $ - | $ 17.20 | $ 92.59 | $ 115.94 |
| Indemnity | $ 4.56 | $ - | $ - | $ - | $ 34.47 | $ 32.32 | $ 80.81 | $ 60.56 | $ - | $ - |
| **Opportunity Wheat** | | | | | | | | | | |
| Rate Yield | | | | | | | | | | 8.0 |
| Planting Price | | | | | | | | | | $ 3.56 |
| Harvest Price | | | | | | | | | | $ 3.28 |
| Proven yield | | | | | | | | | | 29.0 |
| Guarantee yield | | | | | | | | | | 20.3 |
| Sign Up Guarantee | | | | | | | | | | $ 72.27 |
| Harvest Guarantee | | | | | | | | | | $ 66.58 |
| Revenue | | | | | | | | | | $ 26.24 |
| Indemnity | | | | | | | | | | $ 46.03 |
| **Fallow Grain Sorg.** | | | | | | | | | | |
| Rate Yield | | | | | | 73.0 | 12.7 | | | |
| Proven yield calc. | 35.0 | 45.0 | 100.0 | 74.0 | 30.0 | 73.0 | 30.0 | 30.0 | 47.0 | 62.0 |
| Planting Price | $ 2.93 | $ 2.59 | $ 2.70 | $ 2.29 | $ 2.38 | $ 2.34 | $ 2.20 | $ 2.30 | $ 2.71 | $ 2.15 |
| Harvest Price | $ 2.70 | $ 2.67 | $ 2.08 | $ 1.91 | $ 2.00 | $ 1.95 | $ 2.39 | $ 2.15 | $ 1.97 | $ 1.87 |
| Proven yield | 52.6 | 52.6 | 52.6 | 52.6 | 52.6 | 52.6 | 52.6 | 52.6 | 52.6 | 52.6 |
| Guarantee yield | 36.8 | 36.8 | 36.8 | 36.8 | 36.8 | 36.8 | 36.8 | 36.8 | 36.8 | 36.8 |
| Sign Up Guarantee | $ 107.88 | $ 95.36 | $ 99.41 | $ 84.32 | $ 87.63 | $ 86.16 | $ 81.00 | $ 84.69 | $ 99.78 | $ 79.16 |
| Harvest Guarantee | $ 99.41 | $ 98.31 | $ 76.59 | $ 70.33 | $ 73.64 | $ 71.80 | $ 88.00 | $ 79.16 | $ 72.54 | $ 68.85 |
| Revenue | $ 94.50 | $ 120.15 | $ 208.00 | $ 141.34 | $ 46.00 | $ 142.35 | $ 30.38 | $ 17.20 | $ 92.59 | $ 115.94 |
| Indemnity | $ 13.38 | $ - | $ - | $ - | $ 41.63 | $ - | $ 57.62 | $ 67.49 | $ 7.19 | $ - |

LDP's are not estimated. They may not be a part of the next farm bill because they are trade distorting. Senate Ag Committee Chairman Saxby Chambliss stated that "Whether we've concluded [Doha Round] negotiations or not, we've got to have programs that we are satisfied are not trade distorting." Chambliss also said in remarks at a seminar at the Carnegie Endowment for International Peace "I don't want to put my farmers at risk. I don't care whether they are corn farmers in Iowa or wheat farmers in Kansas or cattle farmers in Texas. We don't [want to] lose in any additional case that may be filed as being ... a trade distorting program under the WTO." (Wiesemeyer)

### 2.2 Cost of Production

Costs of production are current actual costs from the study farm. Machinery costs (Table 2.6) are custom rates paid by the farm. Nitrogen fertilizer rates are estimated from removal rates of the crops and charged to that crop. It is assumed that wheat uses 1.25 lbs of nitrogen per bushel and corn and grain sorghum use 0.8 lbs per bushel. Organic matter will release 30lbs of nitrogen per year and nitrogen rate will be allowed to accumulate. Phosphorus will be applied at 20 lbs per acre on the wheat and grain sorghum crops. Zinc will be applied at 1 pound per acre with the phosphorus. These rates of phosphorus and zinc will be enough to maintain levels due to crop failures. The costs of the fertilizers are in Table 2.7. All fertilizer rates are based on the author's experiences. Table 2.6 shows the number of chemical applications by farming practice. The grain sorghum is sprayed pre-harvest to desiccate the crop and stop moisture uptake. Table 2.8 shows the amount of each herbicide applied annually on each crop. Interest costs are current costs paid by the author.

**Table 2.6 Machinery costs**

| Machinery Costs-Custom Rates | |
|---|---|
| Tillage | $5.00 |
| Drilling wheat reduced till | $5.00 |
| Drilling wheat no-till w/fertilizer | $12.00 |
| Planting Corn | $9.00 |
| Planting Grains Sorghum 15" w/fert. | $12.00 |
| Chemical and Fertilizer Application | $3.85 |
| Wheat Harvest | |
| Per acre | $15.00 |
| Hauling per bushel | $0.14 |
| Overage (over 20 bu.) per bushel | $0.15 |
| Corn Harvest | |
| Per acre | $18.00 |
| Hauling per bushel | $0.15 |
| Overage per bushel (None) | $0.00 |
| Sorghum Harvest | |
| Per acre | $14.00 |
| Hauling per bushel | $0.15 |
| Overage (over 30 bu.) per bushel | $0.14 |

| Machinery passes | Reduced Till times | No-till times |
|---|---|---|
| Wht herbicide application | 1 | 1 |
| Corn herbicide application | 4 | 4 |
| Sorghum herbicide application | 5 | 5 |
| RT fallow herbicide application | 1 | 3.5 |
| Tillage | 2.9 | 0 |

**Table 2.7 Costs of Fertilizers**

| Fertilizer | | |
|---|---|---|
| Nitogen/lb liquid | $0.30 | Used for all except reduced till wheat |
| Phos/lb liquid | $0.35 | Used for all except reduced till wheat |
| Zn/lb liquid | $2.00 | Used for all except reduced till wheat |
| N /lb Ammonia | $0.23 | Used for reduced till wheat |
| Phos/lb dry | $0.23 | Used for reduced till wheat |
| Zn/lb dry | $2.00 | Used for reduced till wheat |

**Table 2.8 Herbicide Costs and Rates**

| | | | Wheat | Corn | Sorghum | RT Fallow | NT Fallow |
|---|---|---|---|---|---|---|---|
| Herbicide | Price | Unit | (Ounces of chemical used per acre per year) | | | | |
| Glyphosate | $ 10.00 | per gal | 0 | 104 | 58 | 26 | 91 |
| Dicamba | $ 37.00 | per gal | 0 | 2 | 6 | 2 | 7 |
| 2,4-D | $ 16.00 | per gal | 0 | 12 | 6 | 6 | 21 |
| Rave | $ 1.48 | per oz. | 3 | 0 | 0 | 0 | 0 |
| Harness Extra | $ 32.00 | per gal | 0 | 32 | 0 | 0 | 0 |
| Balance | $ 5.65 | per oz. | 0 | 0.8 | 0 | 0 | 0 |
| Bicep Lite II Magnum | $ 32.50 | per gal | 0 | 0 | 48 | 0 | 0 |

## 2.3 Risk

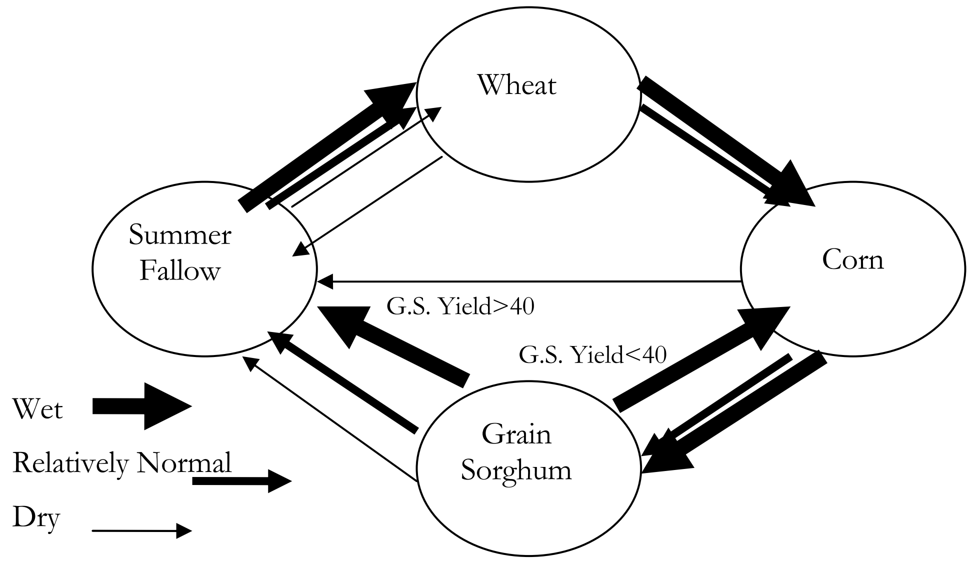
Risk will be defined as the probability of loss and the amount of possible loss for all crops harvested during a calendar year. Risk calculations should consider that farmers are not adverse to higher income years. Burton and Claassen recommend determining a target net revenue and calculating risk based on variability below this standard. The goal is to compare risk between the systems; therefore fixed costs and fixed incomes will not be considered. The term net revenue in this paper will mean net revenue above variable costs. A loss will be defined as the failure to recover variable costs. Since the risk is relative, zero net revenue will be the reference point. The number of losses and average of the worst three years will be calculated for each system and further allocated to each crop. A loss will occur when the average net revenue, only including variable costs, of all crops harvested is less than zero.

## 2.4 Guidelines for Opportunity Cropping

These guidelines direct the cropping decisions for the opportunity cropping rotations. Figures 2.1 and 2.2 are a visual description of the guidelines and are referred to in parentheses in the guidelines. The base rotation for opportunity cropping is wheat-corn-grain sorghum-fallow. Grain sorghum follows corn because it is more drought resistant and is able to use water that corn does not. Corn does not usually yield well behind grain sorghum; but if there is little grain sorghum produced followed by a wet winter, corn following grain sorghum can yield well. Corn only follows poor crops of grain sorghum because of the lower grain sorghum residue production. About 6 to 8 inches of precipitation will be needed before a crop is planted, less when planting wheat in the fall.

This moisture will help to keep the plant growing until flowering. Eight inches will provide roughly two feet of wet soil.

**Figure 2.1 RT Opportunity Cropping Sequence**




*2.4.1 Guidelines for RT Opportunity Cropping*

*2.4.1.1 Wheat stubble*

1. If 7 or more inches of moisture occur between June 15 and May 1, plant wheat stubble to corn. (Medium and wide arrow from wheat to corn on Figure 2.1)

2. If less than 7 inches of moisture occur between June 15 and May 1, summer fallow wheat stubble. (Narrow arrow from wheat to summer fallow on Figure 2.1)

*2.4.1.2 Corn stalks*

1. If 6 or more inches of moisture occur from September 15 to May 1, plant corn stalks to grain sorghum. (Medium and wide arrow from corn to grain sorghum on Figure 2.1)

2. If less than 6 inches of moisture occur September 15 to May 1, summer fallow corn stalks. (Narrow arrow from corn to summer fallow on Figure 2.1)

*2.4.1.3 Grain sorghum stalks*

1. If 8 or less inches of moisture occur from September 15 to May 1, summer fallow grain sorghum stalks. (Narrow arrow from grain sorghum to summer fallow on Figure 2.1)

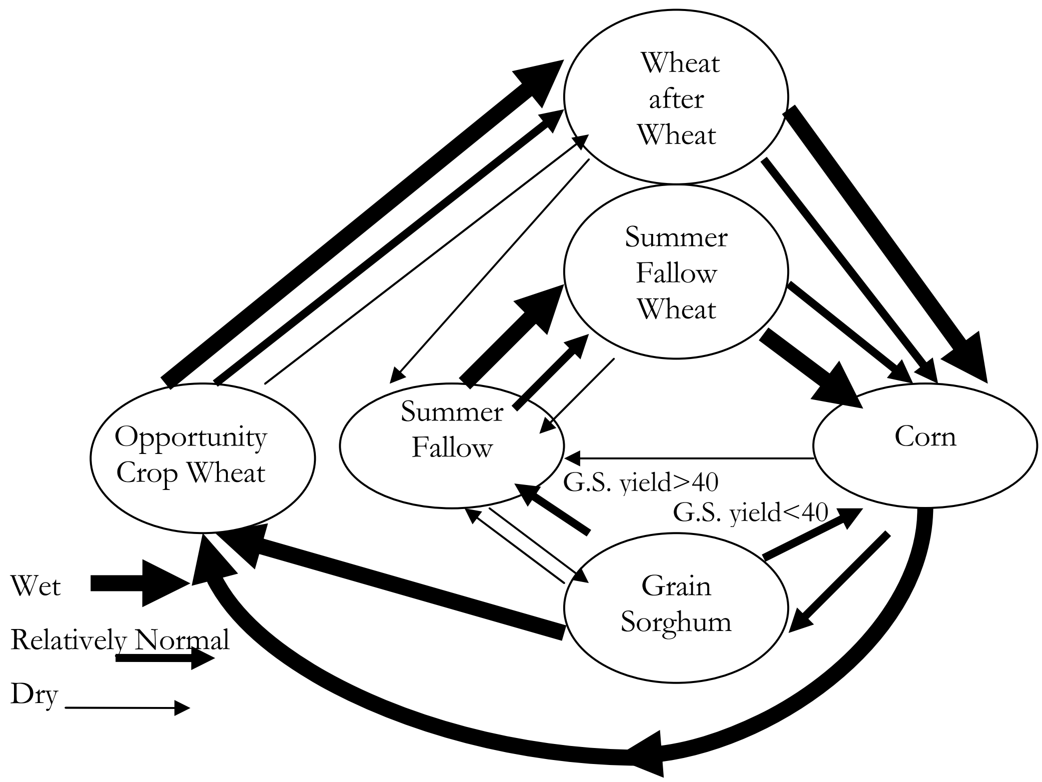
2. If more than 8 inches of moisture occur from September 15 to May 1 and grain sorghum yield is more than 40 bushels per acre, summer fallow grain sorghum stalks. (Medium arrow and wide from grain sorghum to summer fallow on Figure 2.1)

3. If more than 8 inches of moisture occur from September 15 to May 1 and grain sorghum yield is less than 40 bushels per acre, plant grain sorghum stubble to corn. (Wide arrow from grain sorghum to fallow on Figure 2.1)

*2.4.1.4 Summer fallow*

Summer fallow will be planted to wheat. (Arrows from summer fallow to wheat on Figure 2.1)

**Figure 2.2 NT Opportunity Cropping Sequence**




*2.4.2 Guidelines for NT Opportunity Cropping*

*2.4.2.1 Wheat stubble (wheat after wheat or summer fallow wheat on Figure 2.2)*

1. If 6 or more inches of moisture occur between June 15 and May 1, plant wheat stubble to corn. (Medium and wide arrow from wheat to corn on Figure 2.2)

2. If less than 6 inches of moisture occur between June 15 and May 1, summer fallow wheat stubble. (Narrow arrow from wheat to summer fallow on Figure 2.2)

*2.4.2.2 Corn stalks*

1. If 3 inches of moisture occur from September 10 to October 15, plant corn stalks to opportunity crop wheat. Opportunity crop wheat will be defined as wheat planted the same fall as a fall harvested crop. (Wide arrow from corn to opportunity crop wheat on Figure 2.2)

2. If 6 inches of moisture occur from September 15 to May 1, plant corn stalks to grain sorghum. (Medium arrow from corn to grain sorghum on Figure 2.2)

3. If less than 6 inches of moisture occur from September 15 to May 1, summer fallow. (Narrow arrow from corn to summer fallow on Figure 2.2)

*2.4.2.3 Grain sorghum stalks*

1. If 3 inches of moisture occur from September 10 to October 15, plant grain sorghum stalks to opportunity crop wheat. (Wide arrow from grain sorghum to opportunity crop wheat on Figure 2.2)

2. If more than 7 inches of moisture occur from September 15 to May 1 and grain sorghum yield is less than 40, plant grain sorghum stalks to corn. (Medium arrow from grain sorghum to corn on Figure 2.2)

3. If more than 7 inches of moisture occur from September 15 to May 1 and yield is greater than 40, summer fallow grain sorghum stalks. (Narrow and medium arrow from grain sorghum to summer fallow on Figure 2.2)

4. If less than 7 inches of moisture occur from September 15 to May 1, summer fallow grain sorghum stalks. (Narrow and medium arrow from grain sorghum to summer fallow on Figure 2.2)

*2.4.2.4 Opportunity crop wheat*

1. Opportunity crop wheat stubble will be planted to wheat after wheat. (All arrows from opportunity crop wheat to wheat after wheat on Figure 2.2)

2. Wheat after wheat will follow wheat stubble guidelines (2.4.2.1).

*2.4.2.5 Summer fallow*

1. If more than 1 inch of moisture occur from August 15 to October 15, plant summer fallow to wheat in the fall. (Medium and wide arrow from summer fallow to summer fallow wheat on Figure 2.2)

2. If less than 1 inch of moisture occur from August 15 to October 15, plant summer fallow to grain sorghum the next spring. (Narrow arrow from summer fallow to grain sorghum on Figure 2.2)

## CHAPTER 3: RESULTS AND CONCLUSIONS

### 3.1 Results

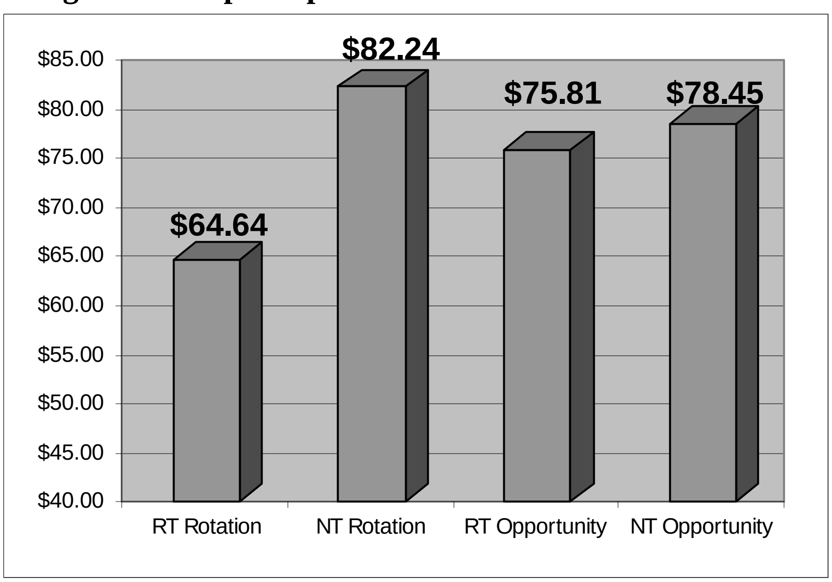
Table 3.1 summarizes the results.

**Table 3.1 Results**

| | Cropping intensity | Avg. Gross income per tillable acre | Avg. gross expense per tillable acre | Avg. Net revenue per tillable acre | Number of Years with losses | Average of 3 worst years |
|---|---|---|---|---|---|---|
| RT Rotation | 66.7% | $80.69 | $64.64 | $16.05 | 1 | $1.19 |
| NT Rotation | 75.0% | $92.88 | $82.24 | $10.65 | 3 | ($4.73) |
| RT Opportunity | 72.5% | $88.03 | $75.81 | $12.22 | 4 | ($11.96) |
| NT Opportunity | 72.5% | $98.47 | $78.45 | $20.02 | 3 | ($5.50) |

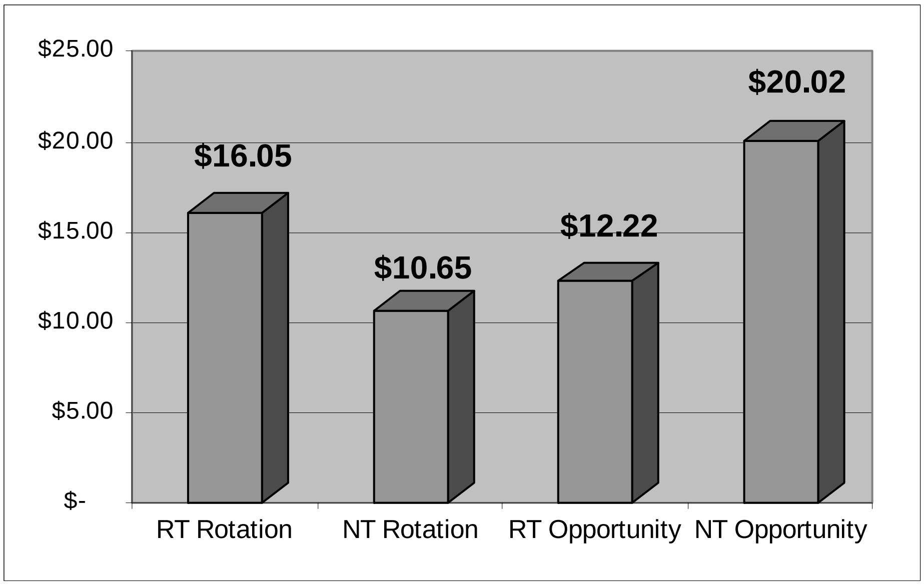
The RT rotation is by definition 66.7% crops and 33.3% fallow. The NT rotation is by definition 75% cropping and 25% fallow. The cropping intensity of both opportunity cropping systems is the same with 72.5% cropping and 27.5% fallow.

**Figure 3.1 Average Gross Expense per Tillable Acre**



Average variable cropping expenses increase by 27 percent when switching from a RT rotation to a NT rotation (Figure 3.1). The RT opportunity cropping expenses are higher than the RT rotation by 17%, but lower than either NT system. NT opportunity cropping lowers variable cropping expenses over the NT rotation by 6%.

**Figure 3.2 Average Net Revenue per Tillable Acre**




NT opportunity cropping with net revenue of $20.02 is the highest net revenue producer, and shows $3.97 per acre more profit than the RT rotation (Figure 3.2). The NT rotation produces the lowest net revenue at $10.65. The RT opportunity cropping produces $3.83 less net revenue than the RT rotation, while NT opportunity cropping produces $9.37 more net revenue than the NT rotation. The NT rotation did produce more gross income per acre than the RT rotation but it was not enough to overcome the greater expense per acre. Net revenue and expense results for each year in each rotation are shown in Tables 3.2 through 3.5. In table 3.2 and 3.3, the rotation proceeds down the chart. In table 3.4 and 3.5, the rotation proceeds across the chart.

**Table 3.2 RT Rotation-Expense and Net Revenue Results per Acre**

| | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|---|---|---|
| Crop | Wheat | Wheat | Wheat | Wheat | Wheat | Wheat | Wheat | Wheat | Wheat | Wheat |
| Total Expense | 53.69 | 63.69 | 77.83 | 81.24 | 55.08 | 59.76 | 32.14 | 49.86 | 31.17 | 53.89 |
| Net Return | 62.28 | 70.95 | 94.40 | 89.15 | 30.54 | 45.79 | 55.63 | 51.61 | 60.35 | 51.43 |
| Crop | Corn | Corn | Corn | Corn | Corn | Corn | Corn | Corn | Corn | Corn |
| Total Expense | 147.80 | 115.05 | 131.72 | 127.61 | 110.40 | 89.92 | 89.30 | 89.74 | 126.78 | 110.37 |
| Net Return | 67.53 | -19.31 | 20.12 | -1.15 | -16.86 | -6.74 | 1.68 | -9.45 | 96.45 | -20.75 |
| Crop | Fallow | Fallow | Fallow | Fallow | Fallow | Fallow | Fallow | Fallow | Fallow | Fallow |
| Total Expense | 24.22 | 24.22 | 24.22 | 24.22 | 24.22 | 24.22 | 24.22 | 24.22 | 24.22 | 24.22 |
| Net Return | -24.22 | -24.22 | -24.22 | -24.22 | -24.22 | -24.22 | -24.22 | -24.22 | -24.22 | -24.22 |
| Yearly Avg. | 35.20 | 9.14 | 30.10 | 21.26 | -3.51 | 4.94 | 11.03 | 5.98 | 44.20 | 2.15 |

**Table 3.3 NT Rotation-Expense and Net Revenue Results per Acre**

| | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|---|---|---|
| Crop | Wheat | Wheat | Wheat | Wheat | Wheat | Wheat | Wheat | Wheat | Wheat | Wheat |
| Total Expense | 61.00 | 82.49 | 90.26 | 91.26 | 72.31 | 68.03 | 38.76 | 59.55 | 37.78 | 60.77 |
| Net Return | 59.31 | 100.23 | 87.04 | 72.49 | 50.77 | 37.51 | 49.01 | 85.73 | 53.74 | 47.84 |
| Crop | Corn | Corn | Corn | Corn | Corn | Corn | Corn | Corn | Corn | Corn |
| Total Expense | 143.37 | 133.50 | 142.04 | 138.81 | 128.39 | 107.71 | 107.14 | 107.54 | 146.89 | 128.56 |
| Net Return | 104.26 | -28.40 | 32.58 | 6.63 | -25.37 | -16.51 | -6.92 | -19.59 | 109.83 | -29.70 |
| Crop | Sorghum | Sorghum | Sorghum | Sorghum | Sorghum | Sorghum | Sorghum | Sorghum | Sorghum | Sorghum |
| Total Expense | 104.13 | 106.67 | 138.47 | 121.90 | 98.70 | 98.65 | 79.58 | 95.94 | 106.62 | 108.28 |
| Net Return | -16.86 | -2.77 | 31.13 | 0.35 | -20.57 | -21.48 | 1.22 | -13.70 | -23.72 | 6.05 |
| Crop | Fallow | Fallow | Fallow | Fallow | Fallow | Fallow | Fallow | Fallow | Fallow | Fallow |
| Total Expense | 28.43 | 28.43 | 28.43 | 28.43 | 28.43 | 28.43 | 28.43 | 28.43 | 28.43 | 28.43 |
| Net Return | -28.43 | -28.43 | -28.43 | -28.43 | -28.43 | -28.43 | -28.43 | -28.43 | -28.43 | -28.43 |
| Yearly Avg. | 29.57 | 10.16 | 30.58 | 12.76 | -5.90 | -7.23 | 3.72 | 6.00 | 27.86 | -1.06 |

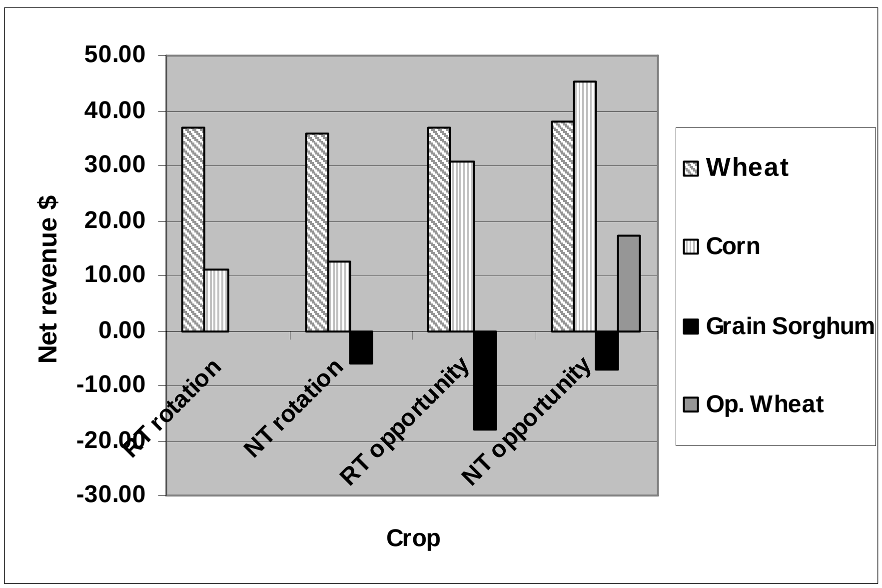
**Table 3.4 RT Opportunity-Expense and Net Revenue Results per Acre**

| | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|---|---|---|
| Crop | Wheat | Corn | Gr. Sorg. | Fallow | Wheat | Corn | Fallow | Wheat | Corn | Gr. Sorg. |
| Total Expense | 55.77 | 112.96 | 133.68 | 24.22 | 57.16 | 87.84 | 24.22 | 51.94 | 128.80 | 114.25 |
| Net Return | 60.19 | -17.23 | 4.21 | -24.22 | 28.46 | -4.65 | -24.22 | 49.52 | 94.43 | -21.30 |
| Crop | Corn | Fallow | Wheat | Corn | Gr. Sorg. | Fallow | Wheat | Corn | Gr. Sorg. | Fallow |
| Total Expense | 132.67 | 24.22 | 79.92 | 125.53 | 104.45 | 24.22 | 49.11 | 87.66 | 110.73 | 24.22 |
| Net Return | 82.66 | -24.22 | 92.32 | 0.94 | -36.94 | -24.22 | 38.66 | -7.36 | -39.56 | -24.22 |
| Crop | Gr. Sorg. | Fallow | Wheat | Corn | Gr. Sorg. | Fallow | Wheat | Corn | Gr. Sorg. | Fallow |
| Total Expense | 109.36 | 24.22 | 78.22 | 125.53 | 104.45 | 24.22 | 34.22 | 87.66 | 110.73 | 24.22 |
| Net Return | -33.49 | -24.22 | 94.02 | 0.94 | -36.94 | -24.22 | 53.55 | -7.36 | -39.56 | -24.22 |
| Crop | Fallow | Wheat | Corn | Gr. Sorg | Fallow | Wheat | Fallow | Wheat | Corn | Gr. Sorg. |
| Total Expense | 24.22 | 65.77 | 130.78 | 120.54 | 24.22 | 61.84 | 24.22 | 51.94 | 138.33 | 114.25 |
| Net Return | -24.22 | 129.71 | 79.17 | 18.38 | -24.22 | 26.67 | -24.22 | 38.55 | 84.91 | 22.30 |
| Yearly Avg. | 21.29 | 16.01 | 67.43 | -0.99 | -17.41 | -6.61 | 10.94 | 18.34 | 25.05 | -11.86 |

**Table 3.5 NT Opportunity-Expense and Net Revenue Results per Acre**

| | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|---|---|---|
| Crop | Wheat | Corn | Gr. Sorg. | Fallow | Wheat | Corn | Fallow | Wheat | Corn | Op. Wheat |
| Total Expense | 63.08 | 112.77 | 141.07 | 28.43 | 74.40 | 86.86 | 28.43 | 61.64 | 139.32 | 55.07 |
| Net Return | 66.87 | -7.67 | 28.53 | -28.43 | 48.68 | 4.34 | -28.43 | 52.80 | 117.40 | 17.29 |
| Crop | Corn | Fallow | Wheat | Corn | Gr. Sorg. | Fallow | Gr. Sorg. | Fallow | Wheat | Corn |
| Total Expense | 103.23 | 28.43 | 92.35 | 128.89 | 101.46 | 28.43 | 98.99 | 28.43 | 39.87 | 110.84 |
| Net Return | 144.40 | -28.43 | 84.95 | 16.55 | -23.34 | -28.43 | 12.74 | -28.43 | 57.97 | -11.99 |
| Crop | Gr. Sorg. | Fallow | Wheat | Corn | Gr. Sorg. | Fallow | Gr. Sorg. | Fallow | Wheat | Corn |
| Total Expense | 108.14 | 28.43 | 96.71 | 128.89 | 101.46 | 28.43 | 98.99 | 28.43 | 39.87 | 107.71 |
| Net Return | -20.87 | -28.43 | 80.59 | 16.55 | -23.34 | -28.43 | 12.74 | -28.43 | 57.97 | -8.86 |
| Crop | Fallow | Wheat | Corn | Gr. Sorg. | Fallow | Gr. Sorg. | Fallow | Wheat | Corn | Op. Wheat |
| Total Expense | 28.43 | 84.58 | 134.45 | 124.71 | 28.43 | 124.39 | 28.43 | 63.22 | 147.26 | 55.07 |
| Net Return | -28.43 | 98.15 | 40.16 | -2.47 | -28.43 | 44.36 | -28.43 | 51.21 | 140.46 | 17.29 |
| Yearly Avg. | 40.49 | 8.40 | 58.56 | 0.55 | -6.61 | -2.04 | -7.85 | 11.79 | 93.45 | 3.43 |

**Figure 3.3Average Net Revenue by Crop**




Wheat's net revenues are similar for all rotations. Corn is much more profitable when grown in an opportunity cropping rotation. For the cropping systems evaluated, grain sorghum on average does not cover variable costs. This appears to largely be due to lower indemnity payments in low yielding years. Grain sorghum's average indemnity payment was $21.90 less than corn for the NT rotation for the 10-year period. Raising grain sorghum as an opportunity crop lowers the net revenues for grain sorghum.

**Figure 3.4 Number of Years with a Negative per Acre Net Revenue by Cropping System**

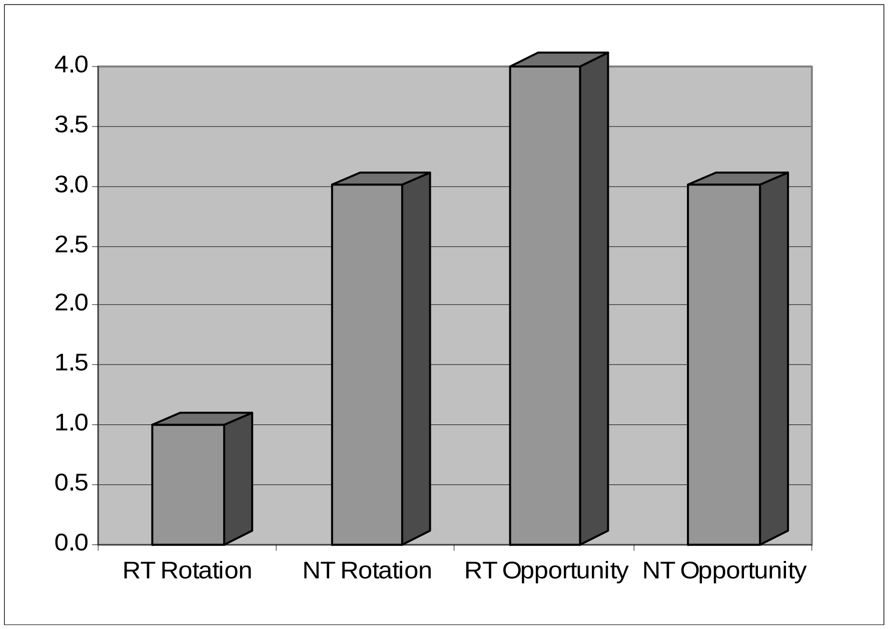
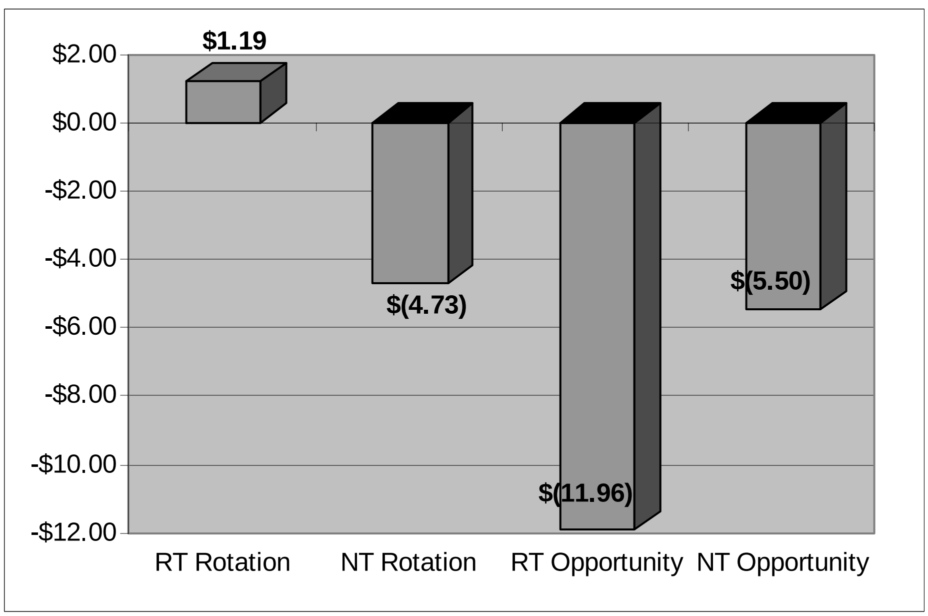
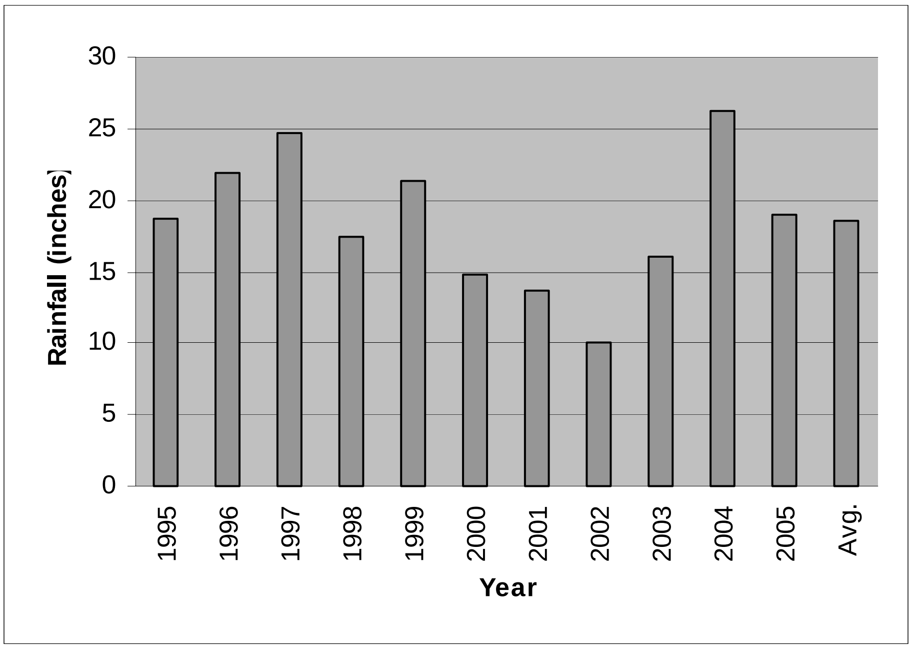



**Figure 3.5 Averages of Worst Three Years of per Acre Net Revenue by Cropping System**




The RT rotation shows only one year in which variable costs were less than revenues. This was the least risky of any farming practice. The RT rotation's average of the worst three years was a positive $1.19. RT opportunity cropping showed the most risk with 4 years of variable costs greater than revenues and a worst three year average of variable costs greater than revenues of a negative $11.96. The NT rotation and NT opportunity cropping both showed 3 years of losses. The NT rotations worst three year average was negative $4.73. The NT opportunity cropping system worst three year average was negative $5.50

**Figure 3.6 Yearly Rainfall at Tribune Unit of the KSU-Southwest Research-Extension Center**




Between 1971 and 2000 annual precipitation averaged 17.44 inches at Tribune (Bond and Nolan). The standard deviation of the annual precipitation for this thirty-year period was 3.59. The 11 year period of this study had and average annual rainfall of 18.53 inches with a standard deviation of 4.83. The timeframe for the study had higher rainfall and higher variability of yearly rainfall.

### 3.2 Interpretation

Switching from the RT rotation to other practices increased variable costs. The RT opportunity practice increased costs because of adding grain sorghum. The NT rotations increased expenses because of the use of more herbicides and more grain sorghum acres. The difference in expenses between RT opportunity cropping and NT opportunity cropping was $2.64 per acre. Opportunity cropping increased net revenue variability. The increase in variable costs explains some of the increased risk of the NT rotation and the opportunity cropping systems.

The RT rotation has higher net revenues than either the NT rotation or the RT opportunity cropping. However in an apparent contradiction, when NT and opportunity cropping are combined in the NT opportunity cropping system, net revenue increases above the RT rotation. What are the reasons for this? The NT rotation appears to be too intensive and does not decrease intensity when adequate subsoil is not available. Opportunity cropping increases the profitability of corn and the rotation by not planting when subsoil is low resulting in lower intensity. In addition, NT increases the net revenues of corn and grain sorghum because of NT yield increases. NT opportunity cropping produced $10.44 more gross income than RT opportunity cropping. This agrees with Dhuyvetter, Thompson, Norwood, and Halverson results that more intensive cropping systems can maintain or increase net revenues, but this study indicates too much intensity can reduce net incomes.

Increasing intensity to increase residues can cause net revenue to decrease. Other ways may need to be found to increase residue levels. One example is wider row widths which results in less destroyed residue.

NT has a crop insurance advantage over RT. The lower proven yield of grain sorghum causes the insurance rate of RT grain sorghum to be $0.202 per dollar of insurance; while the insurance rate for NT opportunity cropped grain sorghum is $0.120 per dollar of insurance. At the same time the average sign up guarantee for NT opportunity cropped grain sorghum is $90.54 per acre. The average sign up guarantee for RT grain sorghum is $71.72 per acre.

Grain sorghum on average does not cover variable costs under any given cropping system. This is due in part to higher insurance costs and lower indemnity payments compared to corn. It cost $0.202 to buy a dollar of insurance for RT grain sorghum. The same coverage cost about $0.11 for corn and $0.09 for wheat. The average sign up guarantee for RT grain sorghum was $71.72. The average sign up guarantee for RT corn was $97.00. Other costs that may cause grains sorghum to be less profitable are the phosphorus and zinc fertilizers at planting used to speed up maturity because of local weather and climate conditions and the use of glyphosate to desiccate the plant at harvest.

The low net revenues of grain sorghum may appear to contradict Schlegel's work; but his studies dealt mostly with grain sorghum planted in wheat stubble. In this study the grain sorghum is planted into corn stalks. Wheat stubble provides a longer fallow period than corn stalks. Opportunity cropping did not increase the profitability of grain sorghum as it did corn.

Although grain sorghum is not profitable as a crop, this study is comparing rotations not crops. The grain sorghum is necessary to increase residues and compete against perennial grasses. Long term NT rotations are difficult to achieve without grain sorghum. As suggested with Lyon, Baltensperger, Blumethal, Burgener, and Harvenson increased cropping intensity lowers the yield of some crops, but the profitability of the cropping system is increased.

Results indicate that NT opportunity cropping has better profits than the RT rotation. If the benefits of switching to NT outweigh the extra risk associated with the cost then producers should switch to NT. The cropping system must lower cropping intensity during dry times. The farmer must maintain the choice not to plant some fields in dry times. NT farming increases net revenues and will increase expenses and risk however the major benefit is preserving soils.

**3.3 Summary**

In the long run, NT opportunity cropping can be as or more profitable than RT eco-fallow using corn, however risks and expenses are greater. Over the 10-year study, the NT opportunity cropping averaged $3.97 per acre more net revenue than the RT rotation. The NT rotation averaged $5.40 per acre less net revenue than the RT rotation. The RT opportunity cropping averaged $3.83 per acre less net revenue than the RT rotation.

Opportunity cropping increased the average net revenue of corn for both RT and NT rotations. NT increased the net revenue of grain sorghum but it still did not cover variable costs. Grain sorghum does leave a valuable residue, competes with perennial grasses and is an important part of making the NT opportunity cropping the most profitable rotation in this study.

Risks of the higher cost cropping systems were significant. The NT farming practices show net revenue loss for the average of all crops harvested in a calendar year of 3 of 10 years. The RT opportunity cropping showed inability to recover variable costs in 4 of 10 years. The RT rotation only showed inability to recover variable costs in 1 year of 10. The average of the worst three years of revenue minus variable costs was $1.19 per acre for the RT rotation, $-4.73 per acre for the NT rotation, $-11.96 per acre for the RT opportunity cropping, and $-5.50 per acre for the NT opportunity cropping.

Long term data comparing NT to RT were not available. Some yields were estimated using other studies. More research needs to be done to compare RT to NT yields in semi-arid areas, such as in western Kansas. In particular, more research needs to be done on the yield of grain sorghum after corn in NT and RT rotations. New guidelines for deciding when to plant grain sorghum need to be studied in order to increase the profitability of grain sorghum.

This analysis reveals that higher intensity NT cropping can increase net revenues as long as intensity is decreased when soil moisture at planting is not adequate, however risks and expenses are greater. These results only apply to this farm, but they indicate that NT is economically viable and the benefits of NT can be realized.

## REFERENCES


Anderson, R.“Benefits of Crop Sequencing.” Paper presented at No-till on the Plains annual meeting, Salina Kansas, 26-27 January 2004.

Barnaby, A. *Historical Corn Market Prices and MPCI price Elections (March 15 Sales Closing).* Agmanager.info Kansas State Research and Extension, 2004. Internet site: www.agmanager.info/crops/insurance/workshops/filespdf/ABkcorn.pdf, (Accessed July 2006).

Barnaby, A. *Historical KCBOT Wheat Market Prices and MPCI Price Elections (Sep 30 Sales Closing).* Agmanager.info Kansas State Research and Extension, 2004. Internet site: www.agmanager.info/crops/insurance/workshops/filespdf/ABkwht.pdf, (Accessed July 2006).

Barnaby, A. *Historical Market and Milo Price Elections and MPCI prices (March 15 Sales Closing).* Agmanager.info Kansas State Research and Extension, 2004. Internet site: www.agmanager.info/crops/insurance/workshops/filespdf/ABkmilo.pdf, (Accessed July 2006).

Bond D., and D. Nolan.“Weather Information for Tribune.” Kansas State University Agr. Exp Sta. and Coop. Ext. Ser. Southwest Research-Extension Center Report of Progress #961, Field Day 2006.

Burton R., and K. Claassen.“Measurement of Farm Risk: Alberta Crop Production: Comment.” *Canadian Journal of Agricultural Economics* 41 (1993): 357-361

Dhuyvetter K.C., and T. Kastens. “Economic Implications of Less-Tillage: A Kansas Perspective.” Paper presented at Risk and Profit Conference, Manhattan, KS 11-12 August 2005.

Dhuyvetter K.C., C.R. Thompson, C.A. Norwood, and A.D. Havlorson. “Economics of Dry Land Cropping System in the Great Plains: A Review.” *Journal of Production Agriculture* 9(1996): 216-222.

Farahani, H. J. and G.A. Peterson. “Dry land Cropping Intensification: A Fundamental Solution to Efficient Use of Precipitation.” *Advances in Agronomy* 64: 197-223, 1998.

Farr, D., Farmers Choice Insurance, Weskan, KS, personal Communication 2006.

Hagney M. “Controlled Traffic, Anyone?” *Leading Edge; The Journal of No-till Agriculture* 4 2005: 227-229.

Lyon, D.J., D.D. Baltensperger, J.M. Blumethal, P.A. Burgener, and R.M. Harvenson. "Eliminating Summer Fallow Reduces Winter Wheat Yields, but Not Necessarily System Profitability." *Crop Science* 44 (3): 855-860 May 2004.

Lyon, D.J., and L. Stone. "Matching Crop Water Use Patterns with Expected Available Moisture." Paper presented at High Plains Dry land Cropping Workshop, Goodland, KS 5 December 2000.

Power, J.F., W. W. Whilhelm, and J.W. Doran. "Crop Residue Effects on Soil Environment and Dry Land Maize and Soya Bean Production." Paper presented at Great Plains Residue Management Conference, Amarillo TX, 15-17 August 1986.

Power, J.F., J.W. Doran, P.T. Koerner, and W. W. Whilhelm. "Long-Term Residual Effects of Crop Residues in Eastern Nebraska." Paper presented at Great Plains Residue Management Conference, Amarillo TX, 15-17 August 1994.

Schlegel, A.J., K.C. Dhuyvetter, C.R. Thompson, and J.L. Havlin. "Agronomic and Economic Impacts of Tillage and Rotations on Wheat and Sorghum." *Journal of Production Agriculture* 12 (4): 629-636 Oct-Dec 1999.

Schlegel, A.J., T. Dumler, and C.R. Thompson. "Feasibility of Four-Year Crop Rotations in the Central High Plains." *Agronomy Journal* 94 (3): 509-517 May-Jun 2002.

Schlegel A., L. Stone, T. Dumler, and C. Thompson. "Effect of No-till on Soil Properties and Grain Yield in a Wheat-Sorghum-Fallow Rotation." Paper presented at Cover Your Acres Winter Conference, Oberlin, KS 3 February 2005.

Schlegel, A.J., C.R. Thompson, and T. Dumler. "Large Scale Dryland Cropping Systems." Kansas State University Agr. Exp Sta. and Coop. Ext. Ser. Southwest Research-Extension Center Report of Progress #961, Field Day 2006.

Smith, E.G. and D.L. Young. "The Economic and Environmental Revolution in Semi-arid Cropping in North America." *Annals of Arid Zone* 39: 347-361, Sep 2000.

Stone, L.R. and A.J. Schlegel. 2006. "Yield - Water Supply Relationships of Grain Sorghum and Winter Wheat." *Agronomy Journal* 98: (in press).

United States Department of Agriculture (USDA). *RMA Premium Calculation*. USDA, 2006. Internet site: www3.rma.usda.gov/apps/premcalc/ (Accessed July 2006).

United States Department of Agriculture (USDA). Corn, Sorghum, and Wheat Prices to Download. Kansas Office of USDA's NASS, Economics and Misc, 2007 Internet site: www.nass.usda.gov/Statistics_by_State/Kansas/Publications/Economics_and_Misc/Distpr/index.asp.

Westfall, D. “Intensive Dryland Cropping Systems – Why do they Work?” Paper presented at High Plains Dry land Cropping Workshop, Goodland, KS 5 December 2000.

Wiesemeyer, J. “Chambliss Interview: Farm Program Changes Are Coming.” www.agweb.com/profarmermembers.asp (Accessed Oct. 2005).