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RISK ANALYSIS OF REDUCED TILLAGE CORN AND SOYBEAN ROTATIONS IN NORTHEASTERN KANSAS USING STOCHASTIC DOMINANCE TECHNIQUES

by

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CHAPTER ONE

INTRODUCTION

Overview

Conservation or reduced tillage is of continuing interest to the corn and soybean growers of Northeast Kansas. The economic aspects of crop production, government program compliance, and soil conservation concerns contribute to this interest. Additional capital investment, as well as crop yields and changing input costs must be considered in the adoption process.

This study provides an economic analysis of two conservation tillage methods and compares them with a typical Northeast Kansas conventional corn - soybean tillage system. These three systems have been the subject of an on-going research study at the Cornbelt Experiment Field, located near Powhattan, Kansas.

The conservation tillage methods include no-till and ridge-till planting. No-till or slot planting involves planting directly into undisturbed residue with pre-plant weed control supplied by herbicides and post-plant weed control achieved with herbicides and mechanical cultivation. Ridge-till planting consists of a small amount of tillage occurring at planting time on a ridge top created by the previous years cultivation. Seeds are then planted into this cleared area. Weed control is accomplished in the same manner as no-till with the addition of the cultivation in ridge-till acting to rebuild the planting ridge for next years crop. Weed control is often more agronomically effective with ridge-till due to the planting time tillage that acts to physically clear the ridge top of both growing weeds and weed seeds. Although not addressed in this study, effective banding of herbicides is made possible by this row clearing action and will result in chemical cost savings. The savings due to herbicide banding are certainly worthy of study in a subsequent work.

The conventional tillage system in this study consists of a disc-field cultivator operation that involves tilling of the entire soil surface. A majority of the residue is buried which may result in increased soil losses compared to the conservation tillage systems.

A wide number of crop rotations are presently used in Northeast Kansas. This study is limited to continuous corn, continuous soybeans, and a corn-soybean rotation. Each of the previously mentioned tillage systems are analyzed within these three rotation frameworks, making for a total of nine cropping system comparisons.

Risk effects of the selected tillage and rotational practices will be examined through net return variability and annual net return averaging. First degree stochastic dominance (FSD), second degree stochastic dominance (SSD), and stochastic dominance with respect to a function (SDWRF) will also be used for determination of preferred systems of individual producers. FSD implies that an individual prefers more income to less income. SSD goes further in implying that the individual receives more satisfaction from equivalent increases in low levels of income than increases at high levels of income. SDWRF is more specific that either FSD or SSD because it allows the examination of the risk preferences at any risk aversion interval.

Statement of the Problem

Conservation tillage systems offer the potential for great savings of costs and soil to a crop producer. However, questions persist about the additional expenses, yield potential, and profitability of these tillage systems. Lane (1976) stated that conservation systems featured: (1) reduced number of tillage operations which offer many benefits to the producer including protection of the soil from wind and water erosion, conservation of moisture from rainfall, improvements in soil physical properties through less soil compaction, reduction in energy use, and lower labor requirements, (2) more flexibility in timing of field operations, and (3) reduction of some production costs.

Reduction of soil tillage is the key to conservation tillage systems. Soil tillage raises production costs through increased fuel usage, wear and tear on machinery, additional labor costs, and reduced timeliness of field operations due to the additional trips over the field. Tillage also increases risk of soil erosion through reduction of protective crop residues on the soil surface. Every tillage trip eliminated results in savings in the above areas.

Tillage has historically been practiced for reasons of weed control, soil aeration, elimination of soil crusting, and increased drying of the soil surface. Obviously tradeoffs that exist between conventional and conservation tillage systems need to be correctly evaluated before a decision is made concerning the adoption of a conservation tillage system.

Objective of Study

The major objective of this study is to evaluate the economic potentials and associated risks of conventional and conservation tillage systems for corn and soybean production in Northeast Kansas. The following questions will be addressed: 1) Which cropping system will provide the highest annual net returns? 2) What is the risk or variability associated with the net returns and yields of each system? 3) How is net return and risk affected by cropping system?

Specific study objectives include:

1) With recommendations from experiment station agronomists and personnel identify reduced tillage cropping systems that are technically feasible for comparison with conventional tillage systems.

2) Collect yield data for each cropping system from the experiment station.

3) Collect regional commodity price data from state authorities.

4) Define a representative case farm for the study area using Kansas State University Farm Management Association data.

5) Establish a machinery complement that is capable of meeting tillage and planting requirements of the case farm within an optimum time period.

6) Estimate the variable and fixed costs of each cropping system based upon characteristics of a typical Northeast Kansas farm using an enterprise budget framework.

7) Examine potential risk of each system by analyzing variance of yields, prices, and net returns.

8) Use FSD, SSD, and SDWRF to provide a ranking of the cropping systems with consideration of net return risk.

Study Area

Yield data used in this study were collected at the Cornbelt Experiment Field, located near Powhattan in Brown County, Kansas. An on-going experiment has been conducted since 1975 that compares a conventional tillage system with no-till and till-plant/ridge-till systems.

Until 1980 the ridge-till system was preceded by a till-plant system. This till-plant system included a soil tillage operation (either discing, chiseling, or both) before the planting operation. Statistical tests show a significant difference between the till-plant yields from years 1975-1979 and the ridge-till yields from years 1980-1984. Severe drought conditions in two of the ridge-till years (1980 and 1983) caused the yield means for the latter time period to be significantly lower than the earlier period. If the two drought year's yields are dropped from the analysis the ridge-till yield means become significantly higher than the till-plant yield means. It was decided that the drought years yields would be included in the analysis to keep net incomes realistic. Since this study is comparing net income variation and risk between tillage and rotation systems, year to year differences in yield will not affect study results. However, it could not be determined if the change in tillage operations significantly affected the crop yields from the 1975-79 period in comparison with the 1980-84 period. Mikesell's 1987 Powhattan study found that grain sorghum and soybean yields were not as affected by the droughty years as were corn yields. No statistically significant differences were found between the 1975-79 and 1980-84 tillage methods in that study.

The corn crop at Powhattan was normally harvested as shelled grain and yields were reported in bushels per acre. No grain was produced during the two drought years previously mentioned so the corn crop was harvested as forage and yields were recorded in pounds of forage per acre. Forage yields were converted to corn yields in bushels by use of the following procedure: The value of corn forage production in Northeast Kansas for each of the drought years was divided by the tons of corn forage produced in those years to arrive at a corn forage value per ton (Farm Facts, 1980-83). The recorded yields in pounds of corn forage per acre were converted to tons of corn forage per acre. Multiplying the tons of corn forage per acre by the corn forage value per ton produced a gross value per acre. This gross value per acre was divided by the per bushel corn price for Northeast Kansas to determine a per acre equivalent yield. This conversion procedure, although not based on sound agronomic principles, is economically satisfactory because this study is based on gross income of crops produced. Yields in bushel per acre are used simply for a standard of comparison throughout the study.

Net returns to management were examined for three planting methods (conventional, no-till, and ridge-till) for each of nine cropping rotations for the years 1975 through 1984.

The cropping systems considered in this study are as shown in Table 1.1.

Table 1.1 Cropping Systems

1. Conventional-Till Continuous Corn ---------------------------- CVCC
2. Conventional-Till Corn - Soybean Rotation ------------------ CVCS
3. Conventional-Till Continuous Soybeans ---------------------- CVSS
4. No-Till Continuous Corn ------------------------------------ NTCC
5. No-Till Corn - Soybean Rotation ---------------------------- NTCS
6. No-Till Continuous Soybeans -------------------------------- NTSS
7. Ridge-Till Continuous Corn --------------------------------- RTCC
8. Ridge-Till Corn - Soybean Rotation ------------------------- RTCS
9. Ridge-Till Continuous Soybeans ----------------------------- RTSS

Soils of Study Area

The Cornbelt Experiment Field is located in Brown County, Kansas near the Missouri River in Northeast Kansas (Figure 1.1). The soils of Brown County belong to the soil group Argiudolls. These soils are found in southeastern Nebraska, eastern Kansas, northeastern Oklahoma, northeastern Missouri, southeastern Iowa, and northern Illinois (see Figure 1.2). The county's soils can generally be divided into upland and lowland areas. The lowlands, located along streams and rivers, range from one-quarter to three-quarters of a mile in width and are generally level and fairly well drained. The uplands are subdivided into smooth to gently sloping areas, strongly sloping areas, and rough hilly areas, all well drained.

A wide range of use suitabilities and management requirements typify Brown County soils. Physical and chemical properties of a soil determine what crops are suited for a particular area and what management practices are needed. These properties vary widely in Brown County. Soil texture ranges from silty clay to gravelly loam. Organic matter levels, natural fertility, and soil pH. vary accordingly. External and internal drainage also varies according to soil type and topography.

Grundy silty clay loam is the dominant soil at the Cornbelt Experiment Field. It is a loess soil that lies nearly level to moderately sloping. Native vegetation on the Grundy soil was big bluestem and little bluestem grasses. The surface layer is dark brown to nearly black, silty clay loam, 8 to 16 inches thick, and is naturally acid. The upper part of the subsoil is black to very dark

Figure 1.1 Location of Brown County in Kansas

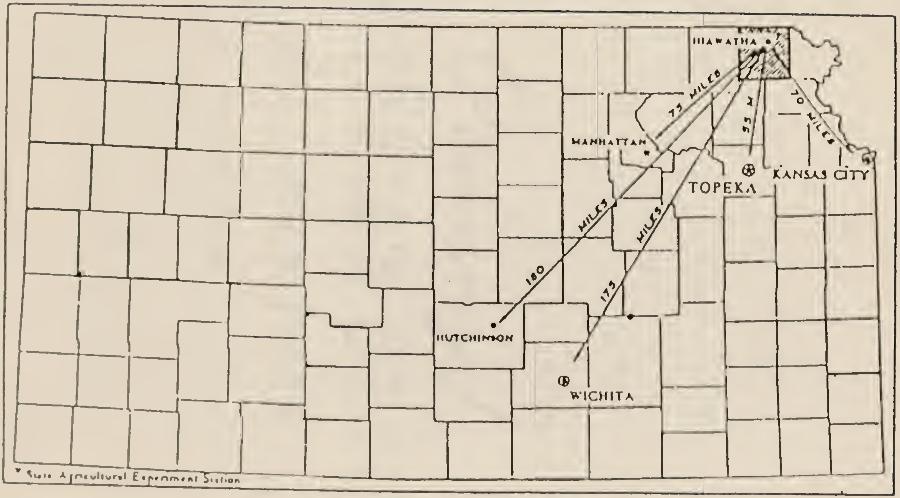
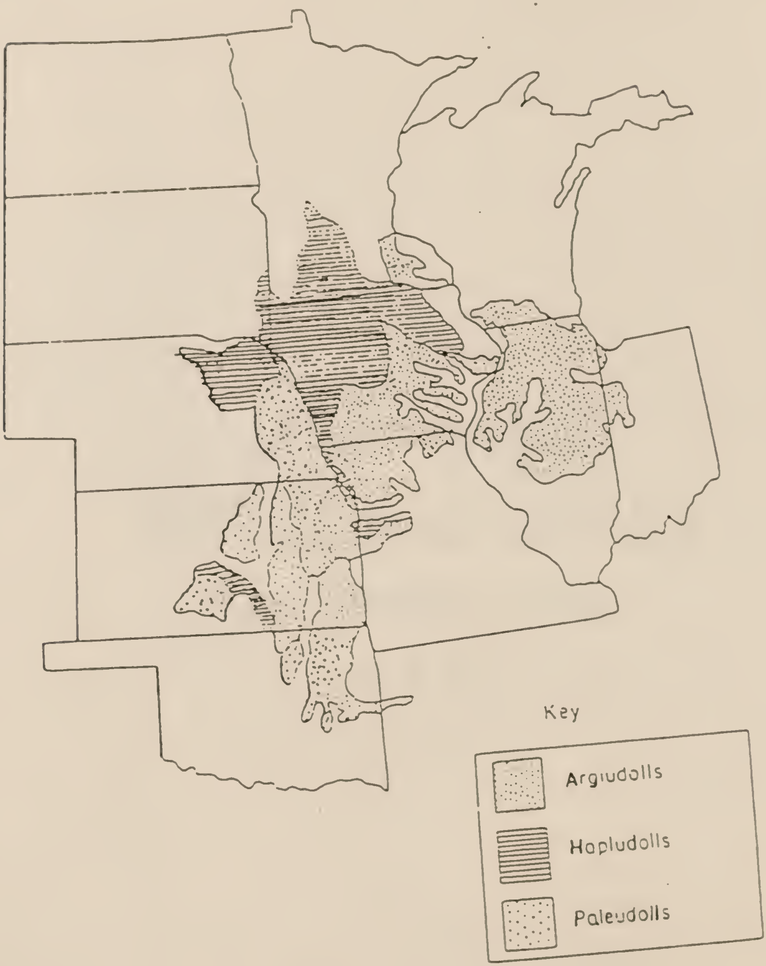


Figure 1.2 Areas where Hapludolls, Agriudolls, and Paleudolls are the dominant soils. (Adapted from National Atlas, Sheet 86, Soils, U.S. Geographic Survey, 1969.)



grayish-brown silty clay loam. The lower part is dark grayish-brown or very dark grayish-brown silty clay to clay. The subsoil is called a "hardpan" or a "gumbo layer" locally because it is sticky when wet and very hard when dry. The subsoil grades to the dark grayish-brown silty clay or silty clay loam parent material (Eikleberry and Templin, 1960).

As slopes increase the A horizon thins rapidly and runoff increases accordingly. Cultivated sloping areas need terraces, grassed waterways, and contour farming to control runoff. Under good management and adequate rainfall Grundy soils can produce excellent yields of corn, grain sorghum, wheat, and soybeans (Long, 1985). Grundy soils can be droughty during periods of high temperatures and low rainfall due to the clayey subsoil. Of the major crops grown in Brown county, corn is most susceptible to yield loss under these conditions.

Climate of the Study Area

Approximately 75% of the annual precipitation occurs during the 172 day average crop growing season. Weather data available from Horton, Kansas, located within 10 miles of the experiment field, show that the months of May and June have the highest rainfall amounts (See Figure 1.3). These two months are when the majority of soil tillage occurs setting the stage for tremendous amounts of soil erosion if a bare soil surface is left exposed. Figure 1.4 gives the annual precipitation from 1900 to present. Average annual rainfall at Horton is 35.07 inches.

Figure 1.3 Average Monthly Precipitation at Horton, Kansas

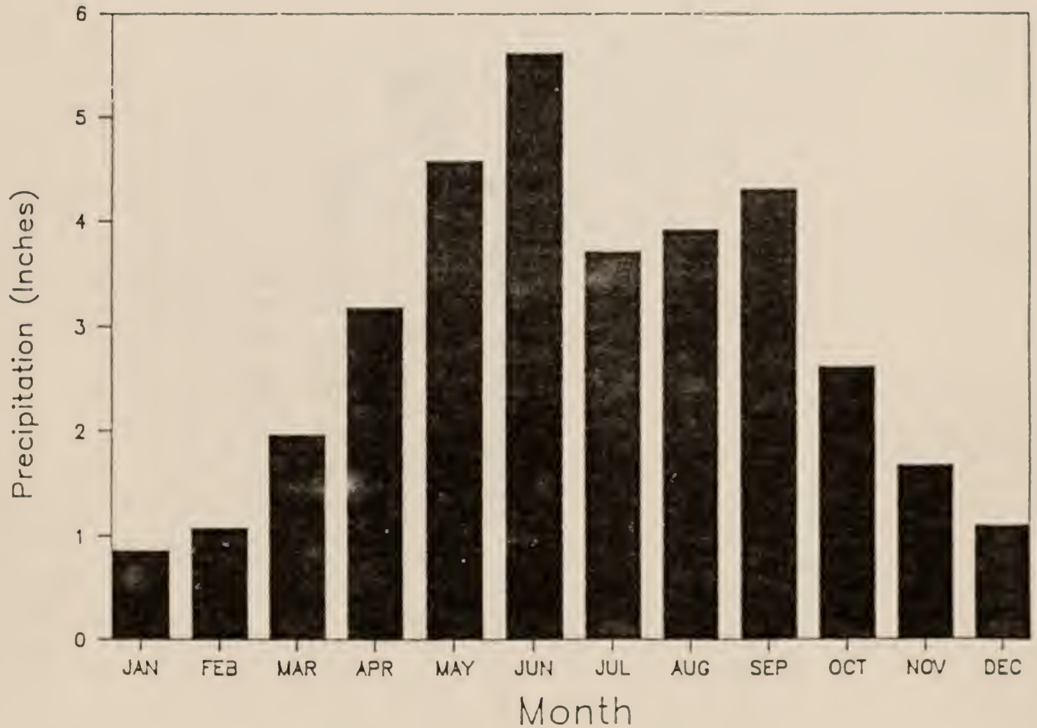


Figure 1.4   Annual Precipitation at Horton, Kansas

CHAPTER TWO

REVIEW OF LITERATURE

There has been a continuing trend away from the moldboard plow as a means of soil tillage since the early days of the twentieth century. Alternatives have been sought that would lessen draft and labor requirements and reduce wind and water erosion of the soil. These alternatives for the moldboard plow have faced difficulties in providing a suitable seed and root bed for the crop as well as in achieving adequate weed and insect control. Only recently have agronomic techniques been refined to the degree where conservation tillage methods can provide a reasonable working alternative to the moldboard plow.

Early Soil Conservation Practices

Americans exploited the soil as they moved westward from the Atlantic coast. Land was plentiful and cheap while the means for preserving the soil were scarce and expensive (Schlebecker, 1975). Recognition of the growing soil erosion problem came early. The United States Department of Agriculture published a farm bulletin in 1894 titled "Washed Soils: How to Prevent and Reclaim Them". H.H. Bennet's 1928 publication, "Soil Erosion -- A National Menace", helped to awaken public concern over a growing problem. Even then, soil erosion was not addressed at the national level until 1935 when the Soil Conservation Service (SCS) was set up by Congress to control wind and water erosion. Small check dams were installed, gully banks were seeded, crop rotation and contour plowing were advocated as means of controlling soil erosion in the eastern part of the country.

Western areas of the United States suffered from tremendous losses of soil caused by wind erosion during these same time periods. The dust bowl years (the worst being 1934 and 1935) made vivid the need for special erosion control practices in the western states. Shelterbelts consisting of planted rows of trees were established in some areas to try to combat the fierce plains winds. Efforts in this area fell short as a whole and it was not until new practices were adopted that progress was made in controlling wind erosion. These practices included leaving residue on the soil surface, strip cropping, and lister planting that left soil surfaces rough and cloddy.

The Soil Erosion Problem

Soil erosion caused by precipitation on United States cropland averages 4.4 ton per acre per year. It is generally thought that soil can regenerate itself if the annual erosion is less than 5 ton per acre. Even though the average erosion level is within tolerable limits approximately 36 million acres have a soil loss exceeding 15 ton per year (Grano, 1985). Soil lost to wind erosion is over and above these amounts.

Water erosion begins with raindrops. Raindrops striking the soil causes particles to become detached and free to move with flowing water. A cover over the soil surface, either of living plants or plant residue, greatly reduces the impact of the raindrops and the resulting erosion (Thompson and Troeh, 1978).

The early spring, both before and after planting, is generally the most critical time for erosion control. The amount of residue remaining from the previous years crop is near a minimum at this time. Also, a crop canopy has not yet developed to protect the soil surface from erosion (Colvin and Gilley, 1987).

Gupta (1985) observed that under reduced or no-till tillage systems, crop residues left at the soil surface after fall harvest act as a barrier to (1) the kinetic energy of rainfall and thus prevent soil detachment and (2) the flow of runoff and thus movement of soil particles.

Raindrop splash is usually the initial step in wind erosion. Rain on bare soil has a smoothing effect which allows the process of saltation to begin. Saltation occurs when small particles of sand are dislodged from the soil surface by the wind and then transported over varying distances. As these particles land they dislodge yet more particles which likewise begin to move. Saltation can result in tremendous losses of soil during an extended period of high winds.

Plaster (1985) found that two costs are incurred by soil erosion: the cost to the farmer and consumer of production losses, and the cost of pollution and sedimentation to society.

The productivity costs of erosion were identified by The Soil Conservation Policy Task Force (1986) as follows: (1) the value of output lost because of the decline in soil productivity, (2) the costs to farmers of things done to offset the loss in productivity, (3) the cost of erosion reduction measures to avoid losses, (4) the cost of damage to growing crops.

Prospective costs of the above mentioned productivity losses were estimated by the task force to be: (1) about $40 million per year for land planted to corn and soybeans. Estimates of nutrient loss to producers (2) range from $1 billion annually (Larson et al., 1983) to about half as much, depending upon fertilizer prices. Estimates for (3) range from $800 million to $1.6 billion per year depending upon the assumed rate of return to capital.

Off-site costs of erosion identified by the task force include costs incurred by: (1) recreational services, (2) water storage facilities, (3) navigational channels and harbors, (4) property values of land near streams and lakes, (5) flood control and damage, (6) sedimentation of water conveyance facilities, (7) water treatment facilities, and (8) steam electric power plants. The task force provides an estimated cost of $1.9 billion in 1980 for these eight categories.

Crosson (1984) provides an estimated present value of productivity losses of $17 million. This estimate is based on the following assumptions: (1) corn and soybean yields will decline, in equal annual increments, by 10 percent over a 100 year period, (2) corn is priced at $3 and soybeans at $7 per bushel, (3) there are 70 million acres in each crop each year, and (4) the annual discount rate is 10 percent. Additional input costs that producers may incur to maintain soil productivity are not included in this estimate.

Soils vary greatly in their ability to maintain productivity in the face of continuing erosion. Deep loess soils such as Monona, found in Western Iowa, are able to produce essentially the same crop yield when eroded as when not eroded, provided the level of fertilization is adequate on both. Monona soils are presently eroding at an estimated rate of 34 tons per acre per year. Studies have shown that if erosion continues at the present rate for the next 200 years, the potential productivity of the soil at the end of that time will be only 2 percent less than it is today (Larson et al., 1983).

In contrast, another soil such as Fayette of eastern Iowa, or Grundy on which this study is based, may have only 8 to 15 inches of topsoil to start with. A moderate rate of erosion on this soil can decrease productivity significantly. This is true of any soil that is shallow to bedrock, coarse materials, or an impermeable clay layer.

Reasons for Tillage

Plaster (1985) sites four common reasons for tillage: (1) weed control, (2) alteration of soil physical properties, (3) crop residue management, and (4) seedbed preparation.

Prior to the advent of effective herbicides tillage was required for both pre-plant and post-emergence weed control. Weed control is important during the early stages of crop growth to prevent weed competition for sunlight, water, and nutrients.

Tillage has also been used over time in an attempt to improve soil physical properties. Soil bulk density is lowered through tillage which allows increased soil aeration and water infiltration. Unfortunately this phenomenon proves to be a temporary one, as additional trips over the field as well as the beating of raindrops soon compacts the soil and returns it to its pre-tillage state.

Only recently have planters and cultivators been developed that can successfully handle large amounts of residue on the soil surface. Prior to this tillage was required to bury the majority of the residue so that a loose, granular seedbed was available for a planting medium.

Crop residue can also slow crop emergence and growth through lower soil temperatures that result from the mulching effect of the soil cover. Imholte and Carter (1987) determined that corn emergence rate was reduced, emergence and silking delayed, and harvest grain moisture increased by planting into large amounts of crop residue. Unincorporated crop residue depresses early season soil temperatures compared to conventional tillage systems (Mock and Erbach, 1977).

Johnson (1985) found that inter-row cultivation can increase yields even when satisfactory weed control has been obtained. These increases may be associated with increased water infiltration and reduced runoff resulting from crust breaking. Crusting of the soil surface is very soil-type specific.

Conventional Tillage Practices

Thompson and Troeh (1978) state that conventional tillage for row crops involves plowing, discing, and harrowing. A chisel plow, sub-soiler or heavy disc may substitute entirely for the plow in the primary tillage operation. The primary operation is designed to lift and aerate the soil as well as bury the majority of the residue. Secondary tillage serves to smooth the rough soil surface left by the plow or chisel while burying still more of the residue. Field cultivators may substitute for the disc in the secondary tillage operation. One-hundred percent of the soil surface is involved in the tillage operations with anywhere from 45 to 100% of the residue being buried prior to planting. The actual amount of residue remaining on the soil surface will vary depending on which implements are used and on how many operations are performed by each implement. Lane and Gaddis (1976) provide a table showing the amount of residue buried by various tillage instruments (Table 2.1).

Table 2.1 Amount of Residue Buried by Tillage Operation

Machine	Residue Buried (%)
Moldboard Plow	100
Disc, Offset	40-50
Disc, Tandem	40-50
Field Cultivator	30-35
Chisel Plow	25
Till Planter (on ridges)	20
Slot Planter (no-till)	0

<u>Conservation Tillage Practices</u>

According to the Conservation Tillage Information Center at least 30% of the soil surface must be covered by residue to be considered conservation tillage (Conservation Tillage Information Center, 1983). As can be seen from Table 2.1, there are various ways to arrive at planting time with enough crop residue remaining on the surface to qualify as a conservation-tilled field. Many producers, through substitution of the chisel plow and field cultivator for the moldboard plow and disc, have been able to maintain a 30% level of residue coverage. This allows them to continue to utilize similar management practices and achieve yields equivalent to the plow/disc system previously used.

Brady (1984) lists several advantages to conservation tillage: (1) decrease in water evaporation, (2) reduction in the time required for land preparation prior to planting, (3) a decrease in the number of tillage operations required with accompanying cost savings.

The residue that remains on the soil surface acts as a protective mulch which helps minimize moisture losses to the atmosphere. Moisture retention is especially valuable in an arid climate. A successful crop in such areas depends heavily on available soil moisture. A mulch also helps protect the soil surface from water and wind erosion by reducing raindrop impact and saltation.

A reduction in the time required for land preparation is an additional advantage to conservation tillage. This enables a producer to either be more timely in his or her field operations or allows more acres to be covered by his or her present labor and machinery supply.

There are obvious cost savings associated with a decrease in the number of tillage operations performed for a particular crop. Savings exist in the areas of fuel, oil, depreciation, repair, and labor, among others.

Numerous problems may accompany a producer's move to conservation tillage. Increased weed, insect, and disease problems are often associated with reductions in tillage. Ritchie and Follett (1983) site four concerns with conservation tillage: (1) Although herbicides have been developed to take the place of tillage for weed control, effectiveness is often variable and increasing environmental concerns raise long-term use questions, (2) similar questions are raised concerning chemical controls of diseases, insects, and nematodes, (3) questions also exist concerning effective fertilization practices for conservation tillage systems, and (4) conservation tillage systems often require additional machinery investment by the producer.

Effects of Conservation Tillage Upon Crop Yields

Effects of conservation tillage on yields varies according to what soil types are involved. Poorly drained soils do not respond as favorably to higher mulch levels as do lighter, well drained soils. Brady (1984) found that crop yields from conventional tillage and conservation tillage were about the same on well drained soils. Brady noted that the flat, poorly drained soils of the eastern corn belt produce lower crop yields under high mulch systems than under conventional tillage. He linked the difference in yields to higher bulk densities and reduced pore space for the conservation tillage systems. In poorly drained areas this results in poor soil aeration and reduced nutrient uptake.

Williams (1986) found that Kansas wheat and grain sorghum yields from conservation tillage systems were significantly higher than those from conventional tillage systems. Yield differences in this study were linked to higher levels of soil moisture in the conservation tillage systems. This phenomenon was also observed by Hargrove (1985) in a comparison of conventional and no-till corn. Rainfall penetrated the soil profile to a greater depth in the no-till plots, perhaps due to reduced-crusting caused by a reduction in rain drop impact.

Increased residue amounts on continuous corn and soybeans increased grain yields in a study done by Wilhelm et al., (1986). The yield increase was attributed to higher amounts of soil water and increased soil temperature compared to plots with reduced amounts of residue.

Modern hybrids and varieties appear to work well with conservation tillage practices and the reduced soil temperatures that accompany such practices. Mock and Erbach (1977) describe corn hybrids as appearing to adapt to minimum tillage practices with no decrease in yields.

Elmore (1987) found that soybean yields were not affected by tillage methods. He compared single and double discing, and no-till tillage methods at Clay Center, Nebraska. Cropping conditions at Clay Center are similar to those at Powhattan. Tyler and Overton (1982) also determined that reduced and no-till soybean production has been successful for full-season and double-crop soybeans. Bharati et al., (1986) stated that plant populations were not reduced by tillage method (disk, chisel plow, and moldboard plow were compared), nor were soybean yields significantly affected.

Crosson (1981) draws an important distinction between short term and long term effects of conservation tillage upon crop yields. In the long term the lower erosion rates associated with conservation tillage give a distinct yield advantage over conventional tillage. Factors that determine the amount of the yield advantage include the degree of erosion control that the conservation tillage system provides, the amount of topsoil present, and the nature of the underlying soil parent material.

Economic Implications of Conservation Tillage

Farm level comparisons of conservation and conventional tillage systems typically involve trade-offs between lower machinery related costs and higher chemical and/or fertilizer costs (Jolly et al., 1982). Weed control and yield levels must be maintained when tillage operations are reduced or eliminated for adoption of the new practices to be economically beneficial to the producer.

Mikesell (1987) found in a study of northeast Kansas grain sorghum and soybean production that no-till systems had higher average net returns than conventional tillage systems. He also found that the standard deviations of net incomes were higher for the conservation tillage systems. Production costs were lowest for the no-till and highest for the ridge-till systems in his study.

Barnes et al., (1986) determined in an East Central Kansas tillage study that a till-plant system would compare favorably with the conventional tillage system when costs and returns were figured for each of the systems. Returns were reduced for the no-till system in that same study.

Reduced tillage systems for wheat and grain sorghum in Western Kansas increased yields over conventional systems, and generated higher net farm incomes in a study by Johnson (1985). This occurred even though the reduced tillage system had higher costs due to greater input requirements and additional machinery needs.

Williams (1986) used Western Kansas grain sorghum and wheat yield data to examine risks and returns of different tillage systems. Returns were compared for both risk neutral and risk averse decision makers using stochastic dominance with respect to a function. He found that managers classified as risk averse prefer conservation tillage systems instead of conventional tillage cropping systems. This was attributed to higher yields associated with reduced energy and labor costs of the conservation tillage systems.

Klemme (1985) found using sensitivity analysis that cost reductions of only $6-8 per acre were necessary to eliminate SSD of conventional and till-plant systems over no-till in corn production. This dominance elimination would depend on the effects of reduced chemical applications on yield expectations and variability. Mikesell (1987) also determined through the use of sensitivity analysis that risk preferences between conservation and conventional tillage systems depended on slight differences in yields between systems.

CHAPTER THREE

CONCEPTIONAL CONSIDERATIONS

Economics of Conservation Tillage

Conservation tillage can play an important role in the reduction of production costs for crop producers. Reducing the number of trips over the field can result in cost savings in machinery, fuel, and labor in many cases. These savings are accompanied by increases in crop yields under certain conditions.

Although not addressed in this study, a major economic benefit of conservation tillage, which accompanies decreasing soil erosion, is the lowering of external costs of erosion. External costs include both on-farm losses of soil productivity and off-farm pollution of air and water. Soil productivity is lowered in two major ways. First, productivity is reduced by decreases in fertility that occur when nutrients accompany soil particles carried by wind or water from farm fields. Increased levels of nutrient applications are then required to maintain production levels. Second, soil organic matter levels decline as erosion continues. This reduces water holding capacity and infiltration rates, micronutrient fertilizer levels, and increases soil density. Situations resulting from organic matter decreases are not readily correctable and pose serious long-term productivity questions.

Off-farm pollution caused by soil erosion is of additional significance. This pollution includes lake and stream soil sedimentation, fertilizer run-off which causes water contamination by nitrates and phosphates, and pesticide run-off that may threaten drinking water supplies and aquatic life.

Enterprise Budgets

The traditional theory of the firm states that the goal of producers is assumed to be profit maximization. This study does not solve for the profit maximization points of each cropping system, but makes the assumption that experiment station agronomists used input levels near these points (marginal factor cost equals marginal value product). The inputs included in the enterprise budgets represent only one point on the producer's production function. This point is assumed to be at or near the profit maximization level.

Decision Theory

Boehlje and Eidman (1984) divided traditional analyses of decision making situations into two classes: business risk and financial risk. Business risk or uncertainty is defined as the inherent uncertainty in the firm independent of the way it is financed. The major sources of business risk in any production period are price and production uncertainty. Financial risk or uncertainty is defined as the added variability of net returns to owner's equity that result from the financial obligation associated with debt financing. This risk results from the concept of leverage. Leverage acts to multiply the potential financial return or loss generated by the production unit. The major source of financial risk is the cost and availability of credit which may fluctuate greatly depending on an individual's situation. For these reasons only the business risk and uncertainty associated with crop production in Northeast Kansas is examined in this study.

Agricultural economists routinely incorporate uncertainties into their decision making analysis since producers operate in an uncertain decision making environment. The Expected Utility Hypothesis has provided the basis for much of the current theory of decision making under uncertainty. The hypothesis states that choices made under uncertainty are affected by the decision maker's preferences and expectations, and that the decision rule used by decision makers is maximization of expected utility.

Stochastic Dominance techniques are a popular method for ranking alternative strategies of decision makers consistent with the Expected Utility Hypothesis. Three different stochastic dominance techniques are currently popular and have been incorporated into this study. First Degree Stochastic Dominance (FSD), Second Degree Stochastic Dominance (SSD), and Stochastic Dominance With Respect to a Function (SDWRF) are the techniques that will be discussed in this study.

Expected Utility Hypothesis

The Expected Utility Hypothesis dates back to Bernoulli's Principle of rational choice which was formulated by Daniel Bernoulli about 200 years ago. It was in the 1940's when the work of von Neumann and Morgenstern showed Bernoulli's principle to be a logical deduction from a number of axioms (Anderson, Dillion, and Hardaker, 1977). The axioms can be expressed as follows:

1. Transitivity: if there exist three lotteries, 'a', 'b', and 'c', and if 'a' is preferred to 'b' and 'b' is preferred to 'c'; then 'a' is preferred to 'c'.

2. Continuity: if an individual has a preference for lottery 'a' over 'b' and 'b' over 'c'; then there exists some probability, p, such that he is indifferent between receiving 'b' and another lottery with probability '1-p' of receiving 'a' and probability 'p' of receiving 'c'.

3. Independence: if lottery 'a' is preferred to lottery 'b' and there exists another lottery 'c'; then a lottery with 'a' and 'c' is preferred to a lottery with 'b' and 'c' as long as the probabilities of receiving 'a' and 'b' are equal.

Bernoulli provided the means for ranking risky prospects in order of preference, with the most preferred being the one with the highest expected utility. Accurately measuring a decision maker's preferences is one of the most serious difficulties with using the Expected Utility Hypothesis. The most direct way is to estimate a decision maker's utility function, which relates all of the possible outcomes of a choice to an exact representation of preferences. King and Robison (1981) offer several reasons for inaccuracy in formulating utility functions: shortcomings in interview procedures, problems in statistical estimation, and the lack of knowledge by individuals about their own preferences.

An efficiency criterion can be used to order choices and will alleviate some of the above listed problems. Restrictions are specified on a decision maker's preferences to allow a partial ordering of choices.

Decision makers are classified according to the restrictions placed upon their utility functions. If the restrictions are rather general in nature, minimal information is needed about the decision maker's preferences and alternatives can be ordered. If enough alternatives are eliminated, decision makers can make a final choice from the efficient alternatives.

A trade-off exists between the discriminatory power and the applicability of the criterion. Efficiency criteria that place few restrictions on preferences, and thus apply to most decision makers, may not eliminate many choices from consideration. Similarly, criteria that identify small efficient sets usually require more specific information about preferences of individuals.

First Degree Stochastic Dominance (FSD), is the most general efficiency criterion utilized. The FSD criterion holds for decision makers who prefer more to less. This is the case when the slope of the decision maker's utility function is greater that zero (positive marginal utility). This criterion holds for most decision makers and limits the usefulness of FSD, as few of the choices under consideration are eliminated. The FSD criterion can be formally stated as:

> Given two cumulative probability distributions, F(x) and G(x), associated with alternative management strategies, it can be shown that the expected utility of F is greater than G, if and only if,
>
> $[F(x)-G(x)] \leq 0$, for all x, and $[F(x)-G(x)] < 0$ for some x.

Second Degree Stochastic Dominance (SSD) is more discriminating than FSD and is widely used in agricultural economics. SSD holds for all decision makers whose utility functions have positive, nonincreasing slopes at all outcome levels. Those individuals are considered risk averse. This risk averse assumption seems reasonable for many, but not necessarily all situations. It is of interest to note that King and Robison (1984) list several studies indicating that risk preferring behavior may be more prevalent than was earlier believed. Also, even though SSD is more discriminating than FSD, it may still not effectively reduce the number of alternatives. SSD can be formally expressed as:

Given two cumulative probability functions, F(x), and G(x), associated with alternative management strategies, it can be shown that for all risk averse decision makers, the expected utility of F is greater than G, if and only if,

$$\int_{-\infty}^{x} [F(x)-G(x)]dx \le 0 \text{ for all } -\infty < x < \infty$$
$$< 0 \text{ for some } x.$$

Stochastic Dominance With Respect to a Function (SDWRF) orders choices for decision makers facing uncertainty by setting upper and lower bounds to define an interval using the Pratt absolute risk aversion function R(x). The absolute risk aversion function is defined by Pratt as:

$$R(x) = -U''(x)/U'(x)$$

where R(x) is the ratio of the rate of change of the slope over the slope of the decision maker's utility function U(x). A particular value of R can be interpreted as the percent reduction in marginal utility per unit of x. If x is measured in dollars, a value of R(x) = 0.0001 indicates that marginal utility is dropping at the rate of 0.01% per dollar.

SDWRF allows researchers to examine classes of utility functions by defining a desired preference interval. The preference interval is bounded by a lower risk aversion coefficient $R_1(x)$ and an upper risk aversion coefficient $R_2(x)$. FSD and SSD are restrictive cases of the SDWRF model, and include large preference intervals: FSD requires an interval with $R_1(x) = -\infty$ and $R2(x) = +\infty$. SSD requires the interval defined by $R_1(x) = 0$ and $R2(x) = +\infty$ (King and Robison, 1981). Dominance by SDWRF can be expressed as:

Given two cumulative probability distributions, F(x) and G(x), associated with alternative management strategies, it can be shown that the expected utility of F is greater than the expected utility of G, if and only if, the utility function, $u_o(x)$ which minimizes

$$\int_{-\infty}^{+\infty} [G(x)-F(x)]u'(x)dx,$$

subject to

$$R_1(x) < -u''(x)/u'(x) < R_2(x) \text{ for all } x.$$

The integral must be positive for F to dominate G. This implies the expected utility of F(x) is always greater than the expected utility of G(x).

Comparison of Stochastic Dominance to Mean Variance Efficiency

EV efficiency is similar to SSD in that decision makers are required to be risk averse and the outcome distributions must be normal. If both these conditions are met EV analysis provides the same efficient set as SSD.

King and Robison (1984) list three reasons why EV efficiency is the most widely used efficiency criterion in risk analysis: (1) EV efficiency is easy to use because means and variances of probability distributions are relatively easy to work with, (2) much of the theoretical work on decision making under uncertainty has been done using the EV criterion, and (3) the EV criterion also work well with quadratic programming. By varying the expected value constraint parametrically, an EV efficient set can be identified. In contrast stochastic dominance requires pair-wise comparisons between alternatives which cannot be incorporated into mathematical programming models.

EV has problems similar to those of SSD which limit its usefulness. Only risk averse decision making is assumed. EV analysis often does not effectively reduce the number of decision alternatives. An additional problem, however, is EV's normality assumption, since much data considered by agricultural economists is skewed.

Strategy rankings for FSD, SSD, EV, MOTAD (Minimization Of the Total Absolute Deviations), and SDWRF were compared by King and Robison (1984). They found that FSD was ineffective in discriminating between alternatives and that the efficient sets of SSD, EV analysis, and MOTAD were identical even though the probability distributions were skewed. SDWRF allowed the possibility of risk preferring behavior at low return levels. Efficient sets of SDWRF were found for two preference intervals - in one case the resulting efficient set was much smaller that the SSD efficient set while in the second case SDWRF reduced the set only slightly.

CHAPTER FOUR

PROCEDURE AND ASSUMPTIONS

Outline of Procedures

The study considers net return distributions from nine different cropping systems based upon actual cropping practices for the years 1975 through 1984. The cropping systems involve three different tillage systems and two major Northeast Kansas crops, corn and soybeans, grown continuously and in rotation.

Stochastic dominance techniques are used to compare the variations of net returns to management of these different cropping systems based upon a representative case farm in Northeast Kansas. The case farm is characterized according to data provided by the Northeast Kansas Farm Management Association.

Enterprise budgets are used to determine the costs and returns of each of the nine cropping systems. Three steps are followed to create the budgets: (1) the system practices are identified, (2) the machinery requirement for each system is determined, and (3) an enterprise budget is formulated for each system based upon technical requirements and economic values.

Identification of the Cropping System Practices. A technically feasible cropping system is determined by identifying the operating inputs and typical field operations for each system. The operating inputs include the variable costs of production, such as seed, fertilizer, and pesticides.

Determination of the Machinery Requirements. The timing and technical requirements of each field operation make it possible to determine the machinery complement of the case farm for each cropping system. Schrock (1976) provides a work sheet to help determine tractor and implement size based upon farm size, planting and tillage constraints, and available field work days.

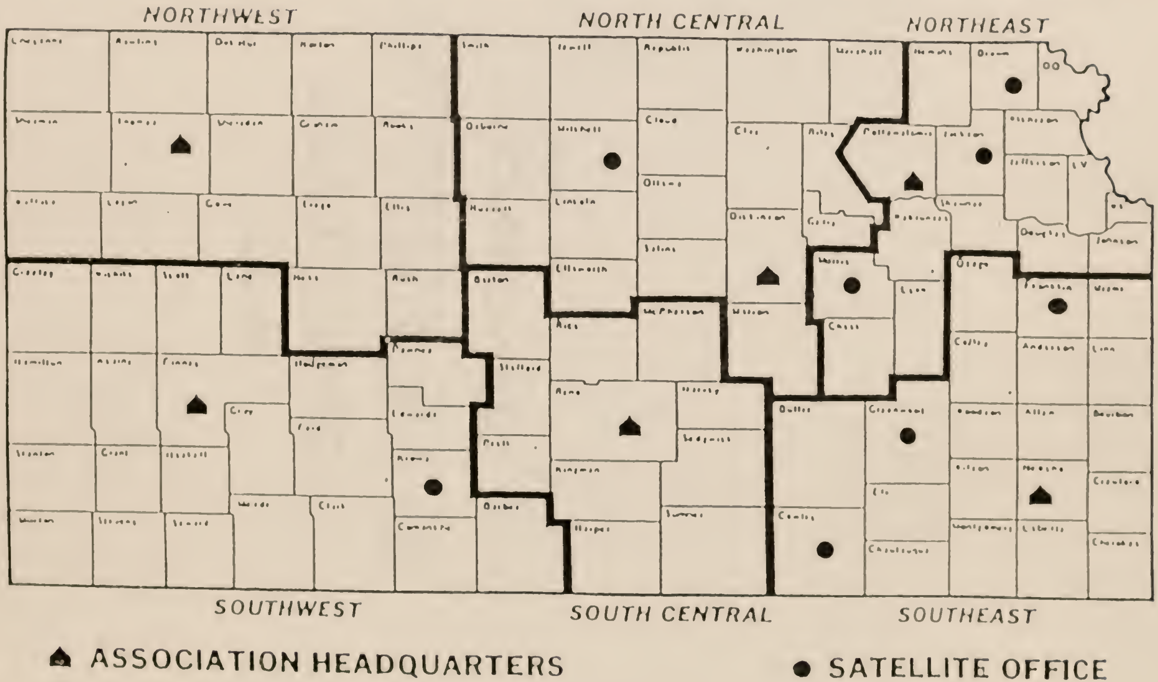
Formulation of the Enterprise Budgets. To prepare the enterprise budgets, costs for labor, fuel, oil, and repairs are calculated for each field operation in each of the cropping systems. The fixed costs of insurance, interest, and depreciation are then determined for each item of machinery in all of the cropping systems. Finally, the cost of the operating inputs are summed with the fixed costs to arrive at the total annual costs of production for each system.

Establishing Farm Size and Tenure

Northeast Kansas Farm Management Association data was used to establish the size and tenure of the case farm (Figure 4.1). The 230 predominantly cash crop dryland farms had an average size of 785 acres, which was rounded to 800 acres for calculation ease. The average farm apportioned 20% of its acreage to wheat (164 acres), 27% to corn (215 acres), 24% to grain sorghum (189 acres), and 28% to soybeans (217 acres). Two reasons led to wheat being dropped from the case farm. One, data concerning wheat cropping practices was not available and two, only row crop tillage practices are of concern to this study. The final acreage used in the analysis was 640 acres (800 total acres - 164 acres wheat = 636, rounded to 640).

Figure 4.1

KANSAS FARM MANAGEMENT ASSOCIATIONS



Owned land in the Northeast Association was shown to be 31% of the farmer's total acreage. The case farm's enterprise budgets assume for ease of calculation that 30% of the land is owned (192 acres) and 70% rented (448 acres).

The Cropping Systems

In 1975 a research project was established at the Cornbelt Experiment Station in Northeastern Kansas near Powhattan to examine conservation tillage corn, grain sorghum, and soybean cropping systems. The cropping systems considered in this study are as shown in Table 4.0. Cropping systems involving grain sorghum have been considered in a previous study (Mikesell, 1987).

Table 4.0 Cropping Systems

1.	Conventional-Till Continuous Corn	CVCC
2.	Conventional-Till Corn - Soybean Rotation	CVCS
3.	Conventional-Till Continuous Soybeans	CVSS
4.	No-Till Continuous Corn	NTCC
5.	No-Till Corn - Soybean Rotation	NTCS
6.	No-Till Continuous Soybeans	NTSS
7.	Ridge-Till Continuous Corn	RTCC
8.	Ridge-Till Corn - Soybean Rotation	RTCS
9.	Ridge-Till Continuous Soybeans	RTSS

Conventional tillage is defined as any tillage system in which 100 percent of the topsoil is mixed or inverted by a tillage operation. Conservation tillage will be defined in this study as any tillage system that has at least 30% of the soil surface covered by crop residue at planting time. No-till and Ridge-till are classified as conservation tillage cropping systems. Herbicides substitute for spring tillage weed control in the ridge-till and no-till cropping systems.

Conventional Tillage. The conventional tillage system in this study makes use of the disc as the primary tillage tool. From 1975-1979 the preplant field operations for the conventional till plots were to shred stalks and chisel in the early spring if the plot contained corn, disc, and then harrow. Soybean plots were disced twice and harrowed prior to planting. In 1980-1984 the procedure for corn was changed to include shredding of cornstalks, discing, and then field cultivating. Soybean plots were disced and field cultivated prior to planting.

Preemergence herbicides were broadcast with planter attachments for both corn and soybeans. Postemergence herbicides were broadcast by custom application in all systems. Insecticides were applied with planter attachments. Herbicide and insecticide application rates can be found in Table 4.1.

Ridge Tillage is a conservation tillage system adaptable to many types of soils including the somewhat poorly drained Grundy silty clay loam soils common to Northeast Kansas. A till planter with sweeps or disc openers is used for planting. During the planting operation, the top few inches of the 8-10 inch tall ridge are removed, with soil, crop residue, growing weeds, and weed seeds being pushed into the inter-row area. Planting then occurs in the resulting, clear, raised seedbed. Cultivation is used during the growing season to rebuild the ridge to its original dimensions.

Ridge planting is gaining interest in several areas of the state and country. Imholte and Carter (1987) reported that no-till yields could

Table 4.1 Chemical Application Rates (Pounds Active Ingredient Per Acre)

	CV Corn	NT Corn	RT Corn	CV Soybean	NT Soybean	RT Soybean
HERBICIDES:						
Alachlor[1]	2.0	2.0	2.0	3.0	3.0	3.0
Atrazine	1.5	1.5	1.5			
Glyphosate	1.0	1.0			1.0	1.0
Metribuzin				.375	.375	.375
Paraquat		.25			.25	.25
2,4-D		.5				.5
INSECTICIDES:						
Chlorpyrifos[2]	1.3	1.3	1.3			

[1]Alachlor - preemergence grass and broadleaf control
Atrazine - pre and postemergence grass and broadleaf control
Glyphosate - postemergence "burndown" grass and broadleaf control
Metribuzin - pre and postemergence grass and broadleaf control
Paraquat - postemergence "burndown" grass and broadleaf control
2,4-D - postemergence broadleaf control

[2]Chlorpyrifos - soil and aerial applied insecticide

equal those of conventional tillage if residue was removed from the row area during planting. This was the case in the Powhattan study. Crops grown in soils that have a high clay content subsoil under a shallow topsoil may benefit from ridge planting not only because of better drainage and/or warmer spring soil temperatures (as compared with no-till), but also from a deeper topsoil for rooting (Seeney and Sisson, 1985).

During 1975-1979 the ridge-till plots were farmed using a till-plant system. The preplant operations for the till-plant tillage were to shred corn stalks and chisel in the early spring. During 1980-1984 the only pre-plant field operation was to shred the corn stalks. Soybean plots were not disturbed prior to planting in either time period. Herbicide application rates for the ridge-till system can be found in Table 4.1.

No-Till farming is another type of conservation tillage system. No-till is a method of planting crops that requires no seedbed preparation other than opening the soil for seed placement at the desired depth (Soil Conservation Society of America, 1982). Thus no-till leaves almost all the previous crop residue on the surface, with the result that wind and water erosion is held to a minimum. This is the ultimate in reduced tillage systems and the most heavily dependent upon the use of herbicides (Giere et al, 1980).

From 1975-1979 the preplant operation for the no-till plots was to shred in the early spring if the plot contained corn stubble. From 1980-1984 shredding of corn stalks occurred during one half of the years. Soybean plots were undisturbed prior to planting throughout the entire 1975-1984 time period. Herbicide application rates for no-till can also be found in Table 4.16.

Tables 4.2 - 4.4 list the required tillage operations for the study based upon the actual farming practices at the Cornbelt Experiment Field during the years 1980-1984. The tables are divided by five day intervals. The tables provide the field work hours per day, the percent of days available for the 5 day interval, the confidence level of days available, and operations provided by both tractors and the combine. The confidence level is the percentage of years in which the study has this many or more field workdays. All confidences are at the 85% level except

Table 4.2 Timetable for Conventional-Till Farming Field Operations for All Crops by Five Day Intervals

Date	Field Hours	% Time Available	Conf. Level	131 HP Tractor	160 HP Tractor	Combine
Apr 1	12	20.0	85	Shred	Disc	
Apr 6	12	20.0	85	Shred	Disc	
Apr 11	12	20.0	85	Shred	Disc	
Apr 16	12	26.7	85	Shred	Disc	
Apr 21	12	26.7	85	Disc	F Cult	
Apr 26	12	26.7	85	Disc	F Cult	
May 1	12	26.7	85	Plant	F Cult	
May 6	12	26.7	85	Plant	F Cult	
May 11	12	26.7	85	Plant	Plant	
May 16	12	20.0	77	Plant	Plant	
May 21	12	20.0	77	Plant	Plant	
May 26	12	20.0	77			
Jun 1	12	26.7	72	Cult	Cult	
Jun 6	12	26.7	72	Cult	Cult	
Jun 11	12	26.7	72	Cult	Cult	
Jun 16	12	28.0	85	Cult	Cult	
Jun 21	12	28.0	85			
Jun 26	12	28.0	85			
Jul 1	12	28.0	85			
Jul 6	12	28.0	85			
Sep 16	7	30.0				Harv
Sep 21	7	30.0				Harv
Sep 26	7	30.0				Harv
Oct 1	7	30.0				Harv
Oct 6	7	30.0				Harv
Oct 11	7	30.0				Harv
Oct 16	7	30.0				Harv
Oct 21	7	30.0				Harv
Oct 26	7	30.0				Harv

Table 4.3 Timetable for No-Till Farming Field Operations for All Crops by Five Day Intervals

Date	Field Hours	% Time Available	Conf. Level	60 HP Tractor	131 HP Tractor	Combine
Apr 1	12	20.0	85		Shred	
Apr 6	12	20.0	85		Shred	
Apr 11	12	20.0	85			
Apr 16	12	26.7	85			
Apr 21	12	26.7	85		Plant	
Apr 26	12	26.7	85		Plant	
May 1	12	26.7	85		Plant	
May 6	12	26.7	85		Plant	
May 11	12	26.7	85		Plant	
May 16	12	20.0	77		Plant	
May 21	12	20.0	77		Plant	
May 26	12	20.0	77			
Jun 1	12	26.7	72	Cult	Cult	
Jun 6	12	26.7	72	Cult	Cult	
Jun 11	12	26.7	72	Cult	Cult	
Jun 16	12	28.0	85			
Jun 21	12	28.0	85			
Jun 26	12	28.0	85			
Jul 1	12	28.0	85			
Jul 6	12	28.0	85			
Sep 16	7	30.0				Harv
Sep 21	7	30.0				Harv
Sep 26	7	30.0				Harv
Oct 1	7	30.0				Harv
Oct 6	7	30.0				Harv
Oct 11	7	30.0				Harv
Oct 16	7	30.0				Harv
Oct 21	7	30.0				Harv
Oct 26	7	30.0				Harv

Table 4.4 Timetable for Ridge-Till Farming Field Operations for All Crops by Five Day Intervals

Date	Field Hours	% Time Available	Conf. Level	60 HP Tractor	170 HP Tractor	Combine
Apr 1	12	20.0	85		Shred	
Apr 6	12	20.0	85		Shred	
Apr 11	12	20.0	85		Shred	
Apr 16	12	26.7	85		F Cult	
Apr 21	12	26.7	85		F Cult	
Apr 26	12	26.7	85		Plant	
May 1	12	26.7	85		Plant	
May 6	12	26.7	85		Plant	
May 11	12	26.7	85		Plant	
May 16	12	20.0	77		Plant	
May 21	12	20.0	77		Plant	
May 26	12	20.0	77			
Jun 1	12	26.7	72	Cult	Cult	
Jun 6	12	26.7	72	Cult	Cult	
Jun 11	12	26.7	72	Cult	Cult	
Jun 16	12	28.0	85			
Jun 21	12	28.0	85			
Jun 26	12	28.0	85			
Jul 1	12	28.0	85			
Jul 6	12	28.0	85			
Sep 16	7	30.0				Harv
Sep 21	7	30.0				Harv
Sep 26	7	30.0				Harv
Oct 1	7	30.0				Harv
Oct 6	7	30.0				Harv
Oct 11	7	30.0				Harv
Oct 16	7	30.0				Harv
Oct 21	7	30.0				Harv
Oct 26	7	30.0				Harv

for the period May 16 through June 15 when the 85% level provided only 3 field workdays for this 31 day period.

Machine Complement Selection

Each of the nine cropping systems require a unique machinery complement to provide the required field operations. The tractor size required to pull each implement also needs to be determined. Shrock (1976) provides a four step worksheet that assists in implement and tractor sizing: (1) identify the critical job, (2) estimate the time available to do the job, (3) determine the size of machinery needed, and, (4) estimate the power requirements of the tillage implements.

This study develops a machinery complement for each system based only upon the needs of the system. This may overstate the costs of each system because rotations with fall crops, i.e. wheat, allow more efficient usage of machinery by spreading annual fixed costs over more acres.

Identify the Critical Job. Equipment must have sufficient capacity to complete field operations within the optimum time period. This insures that timeliness of field operations is not a limiting factor in crop yields. Tractor size can then be determined by the most limiting of these field operations.

It was determined in this study that the planting operation was the most limiting operation for all tillage systems. Optimum planting dates for corn in Northeastern Kansas are April 20 through May 15 (Hickman and Shroyer, 1986) and for soybeans are May 15 through June 25 (Peterson, 1981 and 1984).

Crop quantity and quality depend heavily upon field operation timeliness. To avoid introducing additional variability into the analysis the equipment complement in this study may be slightly oversized to reduce the timeliness problem. In the conventional tillage continuous corn systems a second planter was added to the equipment complement to make more efficient usage of the tractors, and to allow planting to be completed within the optimum time period.

Combine size as well as tractor size must be determined. Combine capacity must be large enough to allow harvesting of the desired acreage within the required time period. The optimum time of harvest for soybeans and corn was assumed to occur during the 46 day period beginning September 15 and ending October 31.

Estimate the Time Available to do the Job. An estimate must be made of the number of days of weather that permit field work to occur. Buller et al., (1976) compiled a list of field work days available based upon the frequency of occurrence of suitable working days in a given year for several different locations in Kansas. Field work days refers to days when the soil moisture is at a level which is satisfactory to perform field operations. Tables 4.2 - 4.4 give the confidence levels used in this study. For harvesting 30% of the days are assumed to be suitable for work.

The number of work hours per day must also be determined. This study uses twelve hour work days throughout with the exception of seven hour days during harvest. Time for machinery maintenance and transportation to and from the field is not included in this twelve hour period. The total running time is determined by multiplying the work hours per day by the field work days available. It is then necessary to schedule all of the desired tillage operations into the total time available. This may require more and/or larger equipment, (see the machinery selection worksheets in Appendices A, B, and C).

Sizing of the Machinery. The field capacity in acres per hour is determined by dividing the total acres covered by a particular field operation by the total running time available. Implement width can then be determined by this formula:

$$W = \frac{F \times 8.25}{S \times E} \qquad (1)$$

where W is the implement swath width in feet, F is the field capacity in acres per hour, S is the speed in miles per hour, and E is the field efficiency in percent. Field efficiency estimates and speeds were found in the 1986 Ag Engineering Yearbook and are summarized in table 4.5.

Table 4.5 Approximate Speeds and Field Efficiencies

Field Operation	Speed (mph)	Field Efficiency
Shredder	5.0	80%
Disc	5.5	85%
Field Cultivator	5.0	85%
Conventional Planter w/herb. & insect.	5.0	60%
No-Till Planter w/herb. & insect.	5.0	60%
Ridge-Till Planter w/herb. & insect.	5.0	60%
Cultivator	4.5	70%
Ridge-Till Cultivator	4.5	70%
Combine	4.0	70%

Estimate Power Requirement. The size of the tillage implement is used to determine the size of the tractor(s) needed. The PTO horsepower requirement for tractors is calculated by taking the implement width times the PTO horsepower requirement per foot of width (Shrock, 1976). The engine horsepower is approximately equal to the PTO horsepower multiplied by 1.1.

In the conventional-till systems the shredding operation required a 131 horsepower tractor. A tractor of this size will pull a 12.0 foot shredder. A 160 horsepower tractor was required to pull the 18.0 foot disc for the primary tillage operation. See machinery selection worksheets in Appendix A for a complete listing.

In the no-till systems the shredding operation required a 131 horsepower tractor. This tractor is also used to plant and cultivate. A second tractor (60 horsepower) was needed to pull an additional cultivator (see Appendix B for machinery selection worksheets).

The ridge-till planting operation required a 170 horsepower tractor. This tractor is also used to shred and cultivate. A second, 60 horsepower tractor was needed to pull an additional cultivator (see Appendix C for machinery selection worksheets).

In all cropping systems herbicide application equipment was sized to match the planter in the equipment complement.

Yields and Prices.

Crop prices are the annual average from the northeastern district of the Kansas Crop and Livestock Reporting Service (see Appendix D). Yield data for corn and soybeans were obtained from the Cornbelt Experiment

Station for the 10-year period in which the tillage study was conducted (see Appendix D). Analysis of variance procedure (ANOVA) using Duncan's multiple range test were used to determine if the mean yield of each cropping system was significantly different at the σ = 0.05 level. No significant difference in yields was detected (see Table 5.12).

As mentioned previously, the conventional tillage field operations during the early years of the study (1975 to 1979), were somewhat different than during the later years, (1980 to 1984), (see Tables 4.6 and 4.7). Tillage practices were changed in 1980 by the elimination of a chiselling operation for both corn and soybeans. Some herbicide changes were also made for both crops. Statistical differences in yield between the early years and the late years were detected at σ = 0.05 in corn when ANOVA was conducted (Appendix H). These differences are attributed to drought years in 1980 and 1983 that drastically reduced corn yields. Since all tillage systems suffered losses it was decided that the yield data was valid and could still be utilized in this analysis. This study makes comparisons only between different cropping systems and not between different cropping years, therefore differences in field operations will uniformly affect all the cropping systems.

Actual field operations for no-till and ridge-till systems are found in Tables 4.8 to 4.11.

Enterprise Budgets.

Enterprise budgets are used to provide a detailed, annual summary of each cropping system's production costs and receipts on a per acre basis. An example of an enterprise budget is provided in Table 4.12.

The first section of the budget labeled VARIABLE COSTS PER ACRE includes all costs based on actual field operations. These costs include labor, seed, pesticides, fertilizers, fuel, oil, machinery repair, custom hire charges, and interest on those variable costs that must be carried for the cropping season.

The second section of the budget labeled FIXED COSTS PER ACRE include costs to the producer that must be covered whether a crop is raised or not. Real estate taxes, interest (or opportunity) costs, and depreciation, interest, and insurance on machinery are all included in this section. The share rent portion of this section is variable and depends on yields and prices at the time that the crop is sold. No yield equals no share rent charge to the producer.

The last section contains a summary of all costs associated with the farming system. This section has a traditional enterprise budget format. The last line of the budget contains an estimate of the net return to management, unpaid labor, and capital to the farm manager for the farming system. A sample worksheet for constructing the enterprise budget is shown in Appendix G.

Table 4.6 Conventional-Till Corn Field Operations

Field Operation	1974-79		1980-84	
	CVCC	CVCS	CVCC	CVCS
Stalk Shredding	X		X	
Discing (First)	X	X	X	X
Discing (Second)				
Discing (Third)				
Chisel	X			
Harrow				
Field Cultivate			X	X
Plant	X	X	X	X
Herbicide	X	X	X	X
Cultivate	X	X	X	X
Harvest	X	X	X	X

Table 4.7 Conventional-Till Soybean Field Operations

Field Operation	1974-79		1980-84	
	CVCS	CVSS	CVCS	CVSS
Stalk Shredding	X		X	
Discing (First)	X	X	X	X
Discing (Second)	X	X	X	
Discing (Third)				
Chisel	X			
Harrow				
Field Cultivate			X	X
Plant	X	X	X	X
Herbicide				
Cultivate	X	X	X	X
Harvest	X	X	X	X

Table 4.8 No-Till Corn Field Operations

Field Operation	1974-79		1980-84	
	NTCC	NTCS	NTCC	NTCS
Discing (First)				
Discing (Second)				
Discing (Third)				
Chisel	X			
Harrow				
Field Cultivate				
Plant	X	X	X	X
Herbicide	X	X	X	X
Cultivate	X	X	X	X
Harvest	X	X	X	X

Table 4.9 No-Till Soybean Field Operations

Field Operation	1974-79		1980-84	
	NTCS	NTSS	NTCS	NTSS
Stalk Shredding	X		X	
Discing (First)				
Discing (Second)				
Discing (Third)				
Chisel				
Harrow				
Field Cultivate				
Plant	X	X	X	X
Herbicide	X	X	X	X
Cultivate	X	X	X	X
Harvest	X	X	X	X

Table 4.10 Ridge-Till Corn Field Operations

Field Operation	1974-79		1980-84	
	RTCC	RTCS	RTCC	RTCS
Stalk Shredding	X		X	
Discing (First)				
Discing (Second)				
Discing (Third)				
Chisel	X			
Harrow				
Field Cultivate				
Plant	X	X	X	X
Herbicide	X	X	X	X
Cultivate	X	X	X	X
Harvest	X	X	X	X

Table 4.11 Ridge-Till Soybean Field Operations

Field Operation	1974-79		1980-84	
	RTCS	RTSS	RTCS	RTSS
Stalk Shredding	X		X	
Discing (First)	X			
Discing (Second)				
Discing (Third)				
Chisel				
Harrow				
Field Cultivate			X	
Plant	X	X	X	X
Herbicide	X	X	X	X
Cultivate	X	X	X	X
Harvest	X	X	X	X

Table 4.12: Conventional Corn - Soybean Enterprise Budget[1]

COST AND RETURNS	CORN	BEANS	TOTAL
VARIABLE COSTS PER ACRE			
1. Labor	3.75	4.66	8.41
2. Seed	13.05	10.20	23.25
3. Herbicide*	15.04	27.56	42.60
4. Insecticide*	0.00	0.00	0.00
5. Fertilizer*	30.45	13.86	44.31
6. Fuel ($/Gallon)=$0.96	3.26	4.04	7.30
7. Oil	0.49	0.61	1.10
8. Equipment repair	12.98	13.97	26.95
9. Custom Hire (Fertilizer Appl.)	2.82	2.82	5.64
10. Interest (1/2 VC @ 14%)			
- Owned Land	5.73	5.44	11.17
- Rented Land	4.46	4.28	8.74
TOTAL VARIABLE COSTS (Owned Land)	87.57	83.16	170.72
TOTAL VARIABLE COSTS (Rented Land)	68.10	65.43	133.53
FIXED COST PER ACRE			
11. Real Estate Taxes ($.50/$100 Land Value)			6.27
12. Interest on Land ($627*.06)			75.24
13. Share Rent CORN (Gross Return * 40%)	86.20		86.20
Share Rent SOYBEANS		75.64	75.64
14. Depreciation on Machinery			47.82
15. Interest on Machinery			44.94
16. Insurance and Housing			6.42
TOTAL FIXED COSTS (Owned Land)			180.69
TOTAL FIXED COSTS (Rented Land)			261.02
TOTAL COSTS PER ACRE (Owned Land)			351.41
TOTAL COSTS PER ACRE (Rented Land)			394.54
YIELD PER ACRE (Bu)	83.53	30.40	
PRICE PER BUSHEL	2.58	6.22	
GROSS RETURN PER ACRE	215.51	189.09	404.60
RETURNS OVER VARIABLE COSTS (Avg.)			259.91
RETURNS OVER TOTAL COSTS (Owned Land)			53.18
RETURNS OVER TOTAL COSTS (Rented Land)			10.05
ANNUAL NET RETURNS PER ACRE (Avg.)			22.99
NET RETURN TO MANAGEMENT (Total Farm)			7356.82

[1] 320 acres corn and 320 acres soybeans.

* Assumes landlord paying 2/5 of herbicide (8.52), 2/5 of insecticide (0.00), and 2/5 of fertilizer (8.86) per acre.

Labor Cost(1)[4] per acre per field operation is equal to the wage rate per hour multiplied by the percentage of years the operation occurs divided by the field capacity (acres per hour) times the number of acres covered by the operation divided by the total crop acres. The summation of these costs for all field operations performed for each system provides the labor cost per acre. The example below calculates the cost per acre of soybeans to shred stalks in a conventional tillage soybeans after corn rotation.

(2) Cost = $/hr. * occur / acres/hr * acres covered / total acres

$0.52 = $6.00 * 50% / 5.8 * 320 / 320

Labor is valued at $6.00 per hour (Figurski and Beech, 1985). In this example the shredder covers 5.8 acres per hour (from machinery selection worksheet) and shredding occurs only 50% of the time (actual tillage practices at Powhattan). There are 320 total acres of soybeans and this shredder is used to shred all of the corn acreage that is to be planted to soybeans.

Seed Expense (2) is based upon actual seeding rates used on the plots. The seeding rate for corn was 17,500 seeds per acre and 60 pounds per acre for soybeans. Seed cost for corn was $0.90 per pound, while soybeans averaged $0.17 per pound (Figurski and Beech, 1985).

Herbicide Cost (3) is based upon actual herbicide application rates at the Corn Belt Experiment Station. Herbicides applied at planting are

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4 Numbers in parenthesis indicate the line on the enterprise budget summary where this information is found.

applied by the operator. Herbicides applied before or after planting are assumed to be custom applied. The application rates and costs are summarized in Appendix G. Prices of herbicides were given by Nilson et al., (1986).

Insecticide Cost (4) is also based upon the actual application rates at the Corn Belt Experiment Station. The only insecticide applied is Lorsban, an organophosphate, which is soil applied to continuous corn acres at a rate of 8.75 pounds per acre for corn rootworm control.

Fertilizer Cost (5) per acre is based upon the actual fertilizer application rates at the Corn Belt Experiment Station. Corn acreage received 130 pounds of nitrogen and 40 pounds of P_2O_5. Only 40 pounds of P_2O_5 was applied to the soybean acreage. All fertilizer is assumed to be custom applied.

Fuel Cost (6) per acre per field operation is equal to the price of fuel ($0.96/gal.) times the occurrence percentage times the fuel use (liters per hectare) converted to gallons per acre times the number of acres covered by the operation divided by the total crop. By summing these costs for all the field operations in the system the fuel cost per acre is obtained.

Oil and Lubricant Cost (7) was assumed to be 15% of the fuel cost (Kletke, 1979). Below is an example showing the calculations for the fuel cost per acre of soybeans to shred stalks in a conventional tillage soybeans after corn rotation.

(3) Cost = $/Gal. * occur. * fuel / 9.353 * acres covered / total acres

$0.37 = $0.96 * 50% * 7.3 / 9.353 * 320 / 320

The fuel price used is the average price in cents per gallon for No. 2 diesel fuel, excluding tax for Kansas in 1985 (USDA, 1986). Fuel consumption in gallons per acre was obtained from a survey of Kansas agricultural producers (Shrock et al., 1985). In the above example the shredder is used 50% of the years over the entire soybean acreage. The tractor consumes 7.3 liters of fuel per hectare which converts to 0.78 gallon per acre.

Repair Cost (8) per acre is estimated based upon the number of hours the tractor and tillage implement are used in each field operation. Rotz (1985) shows the total accumulated repair cost for each piece of equipment is equal to the list price multiplied by the repair coefficient (RC1) times accumulated use (thousands of hours) raised the power of a second repair coefficient (RC2).

Repair costs for some machines tend to be more uniform over their life than those of other machines. Repair costs also tend to increase as the machine ages, however the rate of increase differs between machines. Rotz assigns a coefficient (RC2) to each type of machine to allow for differences between machines. It is necessary to determine each machine's age since repair costs vary as the machine ages. In this study it was assumed that all existing machinery was at an age equal to one half of its depreciable life. Machinery that had to be acquired by the producer for the adoption of the conservation tillage systems includes the openers for the planter in the ridge-till and no-till systems and the ridge-till cultivator. These items were assumed to be purchased new.

For convenience, this study uses the average repair cost per hour of use for computing repair costs per acre. The example below computes the total repair cost of shredding corn stalks prior to planting soybeans in the conventional soybeans after corn rotation. Equation 4 computes the repair cost per hour associated with the implement, and equation 5 computes the repair cost per hour associated with the tractor. Equation 6 computes the total repair cost per hour, and finally, equation 7 computes the total repair cost associated with the field operation.

$$(4)\quad \text{Implement Repair per Hour} = (\text{List} * \text{RC1} * (\text{Life}/1000)^{\wedge}\text{RC2})/\text{Life}$$

$$= (\$4488 * 0.23 * (2000/1000)^{\wedge}1.4)/2000$$

$$= \$1.36 \text{ per hour}$$

$$(5)\quad \text{Tractor Repair per Hour} = (\text{List} * \text{RC1} * (\text{Life}/1000)^{\wedge}\text{RC2})/\text{Life}$$

$$= (\$64,137 * 0.01 * (10000/1000)^{\wedge}2)/10000$$

$$= \$6.41 \text{ per hour}$$

$$(6)\quad \text{Total Repair / Hour} = \text{Implement Repair / Hr} + \text{Tractor Repair / Hr}$$

$$= \$1.36 + \$6.41$$

$$= \$7.77 \text{ per hour}$$

$$(7)\quad \text{Total Repair} = \text{Repair / Hr} * \text{Hours Use} / \text{Crop Acres} * \text{Occur}$$

$$= \$7.77 * 27.5 / 320 * 50\%$$

where List is the 1986 list price of the machine, Life is the estimated life of the machine, Acres Covered are the number of acres covered by this field operation, and Occur is the percentage of the years that the field operation was needed.

<u>Custom Hire</u> (9) includes the cost associated with the application of fertilizer in all the systems and herbicide applications that occur before or after planting. This study assumes that the tenant pays all

custom application expenses. Custom rates for application of liquid fertilizer in Northeast Kansas averaged $2.82 per acre. Rates for herbicide application averaged $3.04 per acre (Kansas Custom Rates, 1985).

Interest Expense (10) is calculated using a simple rate of interest. It was assumed to be equal to one half the sum of the variable cost items times the interest rate (Figurski and Beech, 1985).

Total Variable Cost of rented land is less than the costs of owned land because the landlord is assumed to pay 2/5 of the cost of all yield increasing inputs. This includes fertilizer, herbicide, and insecticide. This is a common rental arrangement in Northeast Kansas.

Real Estate Taxes (11) on owned land are $0.50 per $100.00 of land value. Land value is assumed to be $627.00 per acre. Langemeier (1986) gives the weighted average land value for the Northeastern Farm Management Association to be $777.00 per acre. The Federal Reserve Bank of Kansas City estimated that farm land in Kansas and surrounding states decreased in value 19.3% during 1984 (Kansas City Reserve Bank, 1986). Discounting the land value accordingly places farm land in Northeastern Kansas at $627.00 per acre.

Interest on Land (12) is calculated using a 6% opportunity cost.

Share Rent (13) is equal to the yield multiplied by the landlord's share multiplied by the price. The landlord's share rent of the harvested crop is 40%, a typical figure for northeast Kansas. The yield is the 1975 to 1984 mean obtained from the Corn Belt Experiment Station.

Annual Depreciation for Machinery (14) requires a number of assumptions to be made regarding the machinery complement. The case farm is assumed to have all of the equipment necessary for conventional tillage. All owned equipment was assumed to be aged one half of its depreciable life. Purchased equipment was assumed to be new. Depreciable life was assumed to be 10 years for tractors and combines, 12 years for planting equipment, and 14 years for all other equipment.

The depreciable value for each machinery item was the 1986 list price adjusted for the age of the equipment. The depreciable value is equal to the purchase price (85% of the list price) discounted by a ratio of price indexes for tractors and implements for the appropriate year (Agricultural Outlook, 1975-1986). The salvage value was assumed to be a percentage of the depreciable value (Mohasci, 1982). Annual depreciation is calculated using the straight line method. Table 4.13 shows the annual depreciation for the conventional soybeans after corn equipment complement. The example below calculates the annual depreciation for a 12 foot shredder found in the conventional tillage soybeans after corn rotation.

(8) Depr Value = List * (1 - Discount) * Beg Index / End Index

$2,267.40 = 4464 * (1 - 15%) * 119 / 183

(9) Salv Value = Depr Value * Remain Value Percentage

$266.48 = 2467.40 * 10.8%

(10) Ann Depr = (Depr Value - Salv Value) / Life

$157.21 = (2467.40 - 266.48) / 14

<u>Annual Interest on Machinery</u> (15) is based upon the average value of machinery (one half the depreciable value of the equipment). The interest rate is assumed to be 14%.

Insurance and Housing (16) is assumed to be 1% of the depreciable value. Table 4.13 shows the annual interest, insurance, and housing costs associated with the conventional soybeans after corn rotation. Costs for other tillage systems are discussed in Chapter 5.

Table 4.13 Equipment Annual Depreciation, Insurance, and Interest for Conventional Tillage Corn

Implement	Deprec Value	Salvage Value	Annual Deprec	Annual Insur	Annual Interest
2WD Tractor (131 HP)	$38,162	$11,258	$2,690	$382	$2,671
2WD Tractor (160 HP)	46,544	13,733	3,282	466	3,259
Shredder, 12 Ft.	2,467	266	157	25	173
Disc, 18 Ft.	5,934	641	378	59	415
Field Cult.	5,258	568	335	53	368
Planter	9,138	1,270	656	91	640
Planter	9,138	1,270	656	91	640
Cultivator	2,169	234	138	22	152
Cultivator	2,169	234	138	22	152
Combine	81,923	15,483	6,644	819	5,735
Total Annual Costs			$15,074	$2,030	$14,205

Total Fixed Cost on owned land is equal to the sum of lines 11, 12, 14, 15, and 16 on the enterprise budget (see table 4.12). Rented land combines lines 13 through 16.

Total Costs per Acre are equal to Fixed Costs added to Variable Costs.

Gross Return per Acre is calculated by multiplying yield times the average price.

Returns Over Variable Costs are equal to Gross Return minus Total Variable Costs.

Returns Over Total Costs are equal to Gross Return minus Total Costs.

Annual Net Return per Acre is the weighted average Return Over Total Cost, with 30% of the land owned and 70% rented. Therefore, 2/5 of the crop goes to the landlord on 70% of the land.

Net Return to Management is found by multiplying the Annual Net Returns per Acre by the number of crop acres. Net returns to management reflect net returns after the deduction of all labor costs, interest expenses, and a return to owned land.

CHAPTER FIVE

ANALYSIS

Net returns to management are calculated for the nine cropping systems using ten year average prices and yields. 1985 costs of production are estimated from enterprise budgets developed for the study's case farm. Comparisons are first made of the input requirements for each cropping system, then yield, price, and income variability are examined, and finally stochastic dominance techniques are used to examine the risk associated with each cropping system.

ANNUAL FIELD OPERATIONS

Table 5.1 summarizes annual crop acres and field operations required by each cropping system. Fertilizer applications are custom applied for all cropping systems. Chemical applications occurring on the day of planting are applied by the operator, however all other chemical applications occurring before or after the planting date are assumed to be custom applied.

As a general rule, the number of acres covered for each tillage system is fairly uniform regardless of cropping rotation. The conservation tillage systems add an extra chemical application trip compared to conventional tillage systems but still reduce the total number of acres covered by 640 to 960 acres over the conventional tillage systems. This is due to reductions in pre-plant tillage for the conservation tillage systems.

Table 5.1 Annual Field Operations by Cropping System

	CROPPING SYSTEM								
	CVCC	NTCC	RTCC	CVCS	NTCS	RTCS	CVSS	NTSS	RTSS
Annual Acres:									
Corn	640	640	640	320	320	320			
Soybeans				320	320	320	640	640	640
Total Acres:	640	640	640	640	640	640	640	640	640
OPERATION:									
Pre-plant Tillage									
Corn	2.5	0.0	0.5	2.0	0.0	0.0	0.0	0.0	0.0
Soybeans	0.0	0.0	0.0	3.0	0.5	1.0	2.5	0.0	0.0
Chemical									
Corn	0.0	1.0	1.0	0.0	1.0	1.0	0.0	0.0	0.0
Soybeans	0.0	0.0	0.0	0.0	1.0	1.0	0.0	1.0	1.0
Planting									
Corn	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0
Soybeans	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0
Cultivation									
Corn	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0
Soybeans	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0
SUB-TOTAL:	4.5	3.0	3.5	9.0	6.5	7.0	4.5	3.0	3.0
Fertilizer									
Corn	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0
Soybeans	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0
Harvest									
Corn	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0
Soybeans	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0
TOTAL	6.5	5.0	5.5	13.0	10.5	11.0	6.5	5.0	5.0
ACRES COVERED	4160	3200	3520	4160	3360	3520	4160	3200	3200

ENTERPRISE BUDGETS

The enterprise budgets from the nine cropping systems are listed in Tables 5.2 - 5.10. A ten year average of yields from the Cornbelt Experiment Station, along with a ten year average of annual prices from the Northeast crop reporting district of the Kansas Crop and Livestock Reporting Service are combined with 1985 cost of production estimates to generate the net return to management for each cropping system. Net return to management includes returns to unpaid labor and capital. Gross income, selected costs, and net returns from the enterprise budgets are summarized in Table 5.11. Specific yield and price data can be found later in this chapter on page 81 and in Appendix D.

RESULTS BY CROPPING SYSTEM

The no-till corn - soybean rotation (NTCS) generated the highest average net return of $10,107 followed by the conventional-till corn - soybean rotation (CVCS) which had a net return of $7,357 (see Table 5.11). NTCS also produced the highest gross income ($132,265). Chemical costs were $9062 higher for the NTCS system compared to the CVCS system due to the extra pre-plant herbicide application, but were offset by the $6783 higher repair, depreciation, and interest costs, along with the $2794 lower gross income of the CVCS. Labor and fuel/oil costs were also $1984 higher for the CVCS system which made up part of the average net return difference between these two systems.

The conventional-till continuous soybean rotation (CVSS) system had an average net return of $3555. Gross income was second from the lowest

Table 5.2: Conventional Continuous Corn Enterprise Budget

COST AND RETURNS	CORN
VARIABLE COSTS PER ACRE	
1. Labor	4.32
2. Seed	13.05
3. Herbicide*	15.04
4. Insecticide*	13.65
5. Fertilizer*	30.45
6. Fuel ($/Gallon)=$0.96	3.63
7. Oil	0.54
8. Equipment repair	13.39
9. Custom Hire (Fertilizer Application)	2.82
10. Interest (1/2 VC @ 14%)	
- Owned Land	6.78
- Rented Land	5.13
TOTAL VARIABLE COSTS (Owned Land)	103.68
TOTAL VARIABLE COSTS (Rented Land)	78.37
FIXED COST PER ACRE	
11. Real Estate Taxes ($.50/$100 Land Value)	3.14
12. Interest on Land ($627*.06)	37.62
13. Share Rent CORN (Gross Return * 40%)	75.76
Share Rent SOYBEANS	0.00
14. Depreciation on Machinery	23.55
15. Interest on Machinery	22.20
16. Insurance and Housing	3.17
TOTAL FIXED COSTS (Owned Land)	89.68
TOTAL FIXED COSTS (Rented Land)	124.68
TOTAL COSTS PER ACRE (Owned Land)	193.35
TOTAL COSTS PER ACRE (Rented Land)	203.04
YIELD PER ACRE (Bu)	73.41
PRICE PER BUSHEL	2.58
GROSS RETURN PER ACRE	189.40
RETURNS OVER VARIABLE COSTS (Avg.)	103.44
RETURNS OVER TOTAL COSTS (Owned Land)	-3.95
RETURNS OVER TOTAL COSTS (Rented Land)	-13.65
ANNUAL NET RETURNS PER ACRE (Avg.)	-10.74
NET RETURN TO MANAGEMENT (Total Farm)	-6872.87

* Assumes landlord paying 2/5 of herbicide (6.02), 2/5 of insecticide (5.46), and 2/5 of fertilizer (12.18) per acre.

Table 5.3: Conventional Corn - Soybean Enterprise Budget[1]

COST AND RETURNS	CORN	BEANS	TOTAL
VARIABLE COSTS PER ACRE			
1. Labor	3.75	4.66	8.41
2. Seed	13.05	10.20	23.25
3. Herbicide*	15.04	27.56	42.60
4. Insecticide*	0.00	0.00	0.00
5. Fertilizer*	30.45	13.86	44.31
6. Fuel ($/Gallon)=$0.96	3.26	4.04	7.30
7. Oil	0.49	0.61	1.10
8. Equipment repair	12.98	13.97	26.95
9. Custom Hire (Fertilizer Appl.)	2.82	2.82	5.64
10. Interest (1/2 VC @ 14%)			
- Owned Land	5.73	5.44	11.17
- Rented Land	4.46	4.28	8.74
TOTAL VARIABLE COSTS (Owned Land)	87.57	83.16	170.72
TOTAL VARIABLE COSTS (Rented Land)	68.10	65.43	133.53
FIXED COST PER ACRE			
11. Real Estate Taxes ($.50/$100 Land Value)			6.27
12. Interest on Land ($627*.06)			75.24
13. Share Rent CORN (Gross Return * 40%)	86.20		86.20
Share Rent SOYBEANS		75.64	75.64
14. Depreciation on Machinery			47.82
15. Interest on Machinery			44.94
16. Insurance and Housing			6.42
TOTAL FIXED COSTS (Owned Land)			180.69
TOTAL FIXED COSTS (Rented Land)			261.02
TOTAL COSTS PER ACRE (Owned Land)			351.41
TOTAL COSTS PER ACRE (Rented Land)			394.54
YIELD PER ACRE (Bu)	83.53	30.40	
PRICE PER BUSHEL	2.58	6.22	
GROSS RETURN PER ACRE	215.51	189.09	404.60
RETURNS OVER VARIABLE COSTS (Avg.)			259.91
RETURNS OVER TOTAL COSTS (Owned Land)			53.18
RETURNS OVER TOTAL COSTS (Rented Land)			10.05
ANNUAL NET RETURNS PER ACRE (Avg.)			22.99
NET RETURN TO MANAGEMENT (Total Farm)			7356.82

[1] 320 acres corn and 320 acres soybeans.

* Assumes landlord paying 2/5 of herbicide (8.52), 2/5 of insecticide (0.00), and 2/5 of fertilizer (8.86) per acre.

Table 5.4: Conventional Continuous Soybean Enterprise Budget

COST AND RETURNS	BEANS
VARIABLE COSTS PER ACRE	
1. Labor	3.70
2. Seed	10.20
3. Herbicide*	27.56
4. Insecticide*	0.00
5. Fertilizer*	13.86
6. Fuel ($/Gallon)=$0.96	3.26
7. Oil	0.49
8. Equipment repair	11.98
9. Custom Hire (Fertilizer Application)	2.82
10. Interest (1/2 VC @ 14%)	
- Owned Land	5.17
- Rented Land	4.01
TOTAL VARIABLE COSTS (Owned Land)	79.04
TOTAL VARIABLE COSTS (Rented Land)	61.31
FIXED COST PER ACRE	
11. Real Estate Taxes ($.50/$100 Land Value)	3.14
12. Interest on Land ($627*.06)	37.62
13. Share Rent CORN (Gross Return * 40%)	0.00
Share Rent SOYBEANS	71.73
14. Depreciation on Machinery	21.53
15. Interest on Machinery	20.27
16. Insurance and Housing	2.90
TOTAL FIXED COSTS (Owned Land)	85.46
TOTAL FIXED COSTS (Rented Land)	116.43
TOTAL COSTS PER ACRE (Owned Land)	164.49
TOTAL COSTS PER ACRE (Rented Land)	177.74
YIELD PER ACRE (Bu)	28.83
PRICE PER BUSHEL	6.22
GROSS RETURN PER ACRE	179.32
RETURNS OVER VARIABLE COSTS (Avg.)	112.69
RETURNS OVER TOTAL COSTS (Owned Land)	14.83
RETURNS OVER TOTAL COSTS (Rented Land)	1.58
ANNUAL NET RETURNS PER ACRE (Avg.)	5.56
NET RETURN TO MANAGEMENT (Total Farm)	3555.44

* Assumes landlord paying 2/5 of herbicide (11.02), 2/5 of insecticide (0.00), and 2/5 of fertilizer (5.54) per acre.

Table 5.5: No-Till Continuous Corn Enterprise Budget

COST AND RETURNS	CORN
VARIABLE COSTS PER ACRE	
1. Labor	2.77
2. Seed	13.05
3. Herbicide*	23.72
4. Insecticide*	13.65
5. Fertilizer*	30.45
6. Fuel ($/Gallon)=$0.96	1.89
7. Oil	0.28
8. Equipment repair	11.31
9. Custom Hire (Fert. and Herb. Application)	5.86
10. Interest (1/2 VC @ 14%)	
- Owned Land	7.21
- Rented Land	5.31
TOTAL VARIABLE COSTS (Owned Land)	110.19
TOTAL VARIABLE COSTS (Rented Land)	81.17
FIXED COST PER ACRE	
11. Real Estate Taxes ($.50/$100 Land Value)	3.14
12. Interest on Land ($627*.06)	37.62
13. Share Rent CORN (Gross Return * 40%)	74.15
Share Rent SOYBEANS	0.00
14. Depreciation on Machinery	17.94
15. Interest on Machinery	16.49
16. Insurance and Housing	2.36
TOTAL FIXED COSTS (Owned Land)	77.55
TOTAL FIXED COSTS (Rented Land)	110.94
TOTAL COSTS PER ACRE (Owned Land)	187.74
TOTAL COSTS PER ACRE (Rented Land)	192.10
YIELD PER ACRE (Bu)	71.85
PRICE PER BUSHEL	2.58
GROSS RETURN PER ACRE	185.37
RETURNS OVER VARIABLE COSTS (Avg.)	95.50
RETURNS OVER TOTAL COSTS (Owned Land)	-2.36
RETURNS OVER TOTAL COSTS (Rented Land)	-6.73
ANNUAL NET RETURNS PER ACRE (Avg.)	-5.42
NET RETURN TO MANAGEMENT (Total Farm)	-3469.70

* Assumes landlord paying 2/5 of herbicide (9.49), 2/5 of insecticide (5.46), and 2/5 of fertilizer (12.18) per acre.

Table 5.6: No-Till Corn - Soybean Enterprise Budget[1]

COST AND RETURNS	CORN	BEANS	TOTAL
VARIABLE COSTS PER ACRE			
1. Labor	2.72	3.11	5.83
2. Seed	13.05	10.20	23.25
3. Herbicide*	23.72	47.20	70.92
4. Insecticide*	0.00	0.00	0.00
5. Fertilizer*	30.45	13.86	44.31
6. Fuel ($/Gallon)=$0.96	1.89	2.26	4.15
7. Oil	0.28	0.34	0.62
8. Equipment repair	11.52	12.09	23.61
9. Custom Hire (Fert. and Herb. Appl.)	5.86	5.86	11.72
10. Interest (1/2 VC @ 14%)			
- Owned Land	6.26	6.64	12.91
- Rented Land	4.75	4.93	9.68
TOTAL VARIABLE COSTS (Owned Land)	95.76	101.56	197.32
TOTAL VARIABLE COSTS (Rented Land)	72.57	75.43	148.00
FIXED COST PER ACRE			
11. Real Estate Taxes ($.50/$100 Land Value)			6.27
12. Interest on Land ($627*.06)			75.24
13. Share Rent CORN (Gross Return * 40%)	88.15		88.15
Share Rent SOYBEANS		77.18	77.18
14. Depreciation on Machinery			38.42
15. Interest on Machinery			35.30
16. Insurance and Housing			5.04
TOTAL FIXED COSTS (Owned Land)			160.27
TOTAL FIXED COSTS (Rented Land)			244.09
TOTAL COSTS PER ACRE (Owned Land)			357.59
TOTAL COSTS PER ACRE (Rented Land)			392.09
YIELD PER ACRE (Bu)	85.42	31.02	
PRICE PER BUSHEL	2.58	6.22	
GROSS RETURN PER ACRE	220.38	192.94	413.33
RETURNS OVER VARIABLE COSTS (Avg.)			250.53
RETURNS OVER TOTAL COSTS (Owned Land)			55.74
RETURNS OVER TOTAL COSTS (Rented Land)			21.23
ANNUAL NET RETURNS PER ACRE (Avg.)			31.58
NET RETURN TO MANAGEMENT (Total Farm)			10107.10

[1] 320 acres corn and 320 acres soybeans.

* Assumes landlord paying 2/5 of herbicide (14.18), 2/5 of insecticide (0.00), and 2/5 of fertilizer (8.86) per acre.

Table 5.7: No-Till Continuous Soybean Enterprise Budget

COST AND RETURNS	BEANS
VARIABLE COSTS PER ACRE	
1. Labor	2.67
2. Seed	10.20
3. Herbicide*	47.20
4. Insecticide*	0.00
5. Fertilizer*	13.86
6. Fuel ($/Gallon)=$0.96	1.87
7. Oil	0.28
8. Equipment repair	10.52
9. Custom Hire (Fert. and Herb. Application)	5.86
10. Interest (1/2 VC @ 14%)	
- Owned Land	6.47
- Rented Land	4.76
TOTAL VARIABLE COSTS (Owned Land)	98.93
TOTAL VARIABLE COSTS (Rented Land)	72.80
FIXED COST PER ACRE	
11. Real Estate Taxes ($.50/$100 Land Value)	3.14
12. Interest on Land ($627*.06)	37.62
13. Share Rent CORN (Gross Return * 40%)	0.00
Share Rent SOYBEANS	72.53
14. Depreciation on Machinery	17.18
15. Interest on Machinery	15.84
16. Insurance and Housing	2.26
TOTAL FIXED COSTS (Owned Land)	76.04
TOTAL FIXED COSTS (Rented Land)	107.81
TOTAL COSTS PER ACRE (Owned Land)	174.97
TOTAL COSTS PER ACRE (Rented Land)	180.60
YIELD PER ACRE (Bu)	29.15
PRICE PER BUSHEL	6.22
GROSS RETURN PER ACRE	181.31
RETURNS OVER VARIABLE COSTS (Avg.)	100.67
RETURNS OVER TOTAL COSTS (Owned Land)	6.35
RETURNS OVER TOTAL COSTS (Rented Land)	0.71
ANNUAL NET RETURNS PER ACRE (Avg.)	2.40
NET RETURN TO MANAGEMENT (Total Farm)	1535.81

* Assumes landlord paying 2/5 of herbicide (18.88), 2/5 of insecticide (0.00), and 2/5 of fertilizer (5.54) per acre.

Table 5.8: Ridge-Till Continuous Corn Enterprise Budget

COST AND RETURNS	CORN
VARIABLE COSTS PER ACRE	
1. Labor	3.29
2. Seed	13.05
3. Herbicide*	22.33
4. Insecticide*	13.65
5. Fertilizer*	30.45
6. Fuel ($/Gallon)=$0.96	2.26
7. Oil	0.34
8. Equipment repair	13.70
9. Custom Hire (Fert. and Herb. Application)	5.86
10. Interest (1/2 VC @ 14%)	
- Owned Land	7.35
- Rented Land	5.48
TOTAL VARIABLE COSTS (Owned Land)	112.27
TOTAL VARIABLE COSTS (Rented Land)	83.84
FIXED COST PER ACRE	
11. Real Estate Taxes ($.50/$100 Land Value)	3.14
12. Interest on Land ($627*.06)	37.62
13. Share Rent CORN (Gross Return * 40%)	73.82
Share Rent SOYBEANS	0.00
14. Depreciation on Machinery	20.03
15. Interest on Machinery	18.64
16. Insurance and Housing	2.66
TOTAL FIXED COSTS (Owned Land)	82.09
TOTAL FIXED COSTS (Rented Land)	115.15
TOTAL COSTS PER ACRE (Owned Land)	194.36
TOTAL COSTS PER ACRE (Rented Land)	198.99
YIELD PER ACRE (Bu)	71.53
PRICE PER BUSHEL	2.58
GROSS RETURN PER ACRE	184.55
RETURNS OVER VARIABLE COSTS (Avg.)	92.18
RETURNS OVER TOTAL COSTS (Owned Land)	-9.81
RETURNS OVER TOTAL COSTS (Rented Land)	-14.44
ANNUAL NET RETURNS PER ACRE (Avg.)	-13.05
NET RETURN TO MANAGEMENT (Total Farm)	-8354.54

* Assumes landlord paying 2/5 of herbicide (8.93), 2/5 of insecticide (5.46), and 2/5 of fertilizer (12.18) per acre.

Table 5.9: Ridge-Till Corn - Soybean Enterprise Budget[1]

COST AND RETURNS	CORN	BEANS	TOTAL
VARIABLE COSTS PER ACRE			
1. Labor	2.72	3.11	5.83
2. Seed	13.05	10.20	23.25
3. Herbicide*	22.33	46.96	69.29
4. Insecticide*	0.00	0.00	0.00
5. Fertilizer*	30.45	13.86	44.31
6. Fuel ($/Gallon)=$0.96	1.89	2.24	4.13
7. Oil	0.28	0.34	0.62
8. Equipment repair	13.22	14.29	27.51
9. Custom Hire (Fert. and Herb. Appl.)	5.86	5.86	11.72
10. Interest (1/2 VC @ 14%)			
- Owned Land	6.29	6.78	13.07
- Rented Land	4.81	5.08	9.89
TOTAL VARIABLE COSTS (Owned Land)	96.09	103.64	199.73
TOTAL VARIABLE COSTS (Rented Land)	73.50	77.60	151.10
FIXED COST PER ACRE			
11. Real Estate Taxes ($.50/$100 Land Value)			6.27
12. Interest on Land ($627*.06)			75.24
13. Share Rent CORN (Gross Return * 40%)	85.45		85.45
Share Rent SOYBEANS		73.10	73.10
14. Depreciation on Machinery			43.16
15. Interest on Machinery			40.20
16. Insurance and Housing			5.74
TOTAL FIXED COSTS (Owned Land)			170.61
TOTAL FIXED COSTS (Rented Land)			247.65
TOTAL COSTS PER ACRE (Owned Land)			370.34
TOTAL COSTS PER ACRE (Rented Land)			398.75
YIELD PER ACRE (Bu)	82.80	29.38	
PRICE PER BUSHEL	2.58	6.22	
GROSS RETURN PER ACRE	213.62	182.74	396.37
RETURNS OVER VARIABLE COSTS (Avg.)			230.68
RETURNS OVER TOTAL COSTS (Owned Land)			26.03
RETURNS OVER TOTAL COSTS (Rented Land)			-2.38
ANNUAL NET RETURNS PER ACRE (Avg.)			6.14
NET RETURN TO MANAGEMENT (Total Farm)			1964.98

[1] 320 acres corn and 320 acres soybeans.

* Assumes landlord paying 2/5 of herbicide (13.86), 2/5 of insecticide (0.00), and 2/5 of fertilizer (8.86) per acre.

Table 5.10: Ridge-Till Continuous Soybean Enterprise Budget

COST AND RETURNS	BEANS
VARIABLE COSTS PER ACRE	
1. Labor	2.67
2. Seed	10.20
3. Herbicide*	46.96
4. Insecticide*	0.00
5. Fertilizer*	13.86
6. Fuel ($/Gallon)=$0.96	1.87
7. Oil	0.28
8. Equipment repair	12.22
9. Custom Hire (Fert. and Herb. Application)	5.86
10. Interest (1/2 VC @ 14%)	
- Owned Land	6.57
- Rented Land	4.87
TOTAL VARIABLE COSTS (Owned Land)	100.49
TOTAL VARIABLE COSTS (Rented Land)	74.46
FIXED COST PER ACRE	
11. Real Estate Taxes ($.50/$100 Land Value)	3.14
12. Interest on Land ($627*.06)	37.62
13. Share Rent CORN (Gross Return * 40%)	0.00
Share Rent SOYBEANS	71.03
14. Depreciation on Machinery	19.03
15. Interest on Machinery	17.72
16. Insurance and Housing	2.53
TOTAL FIXED COSTS (Owned Land)	80.04
TOTAL FIXED COSTS (Rented Land)	110.31
TOTAL COSTS PER ACRE (Owned Land)	180.53
TOTAL COSTS PER ACRE (Rented Land)	184.78
YIELD PER ACRE (Bu)	28.55
PRICE PER BUSHEL	6.22
GROSS RETURN PER ACRE	177.58
RETURNS OVER VARIABLE COSTS (Avg.)	95.31
RETURNS OVER TOTAL COSTS (Owned Land)	-2.95
RETURNS OVER TOTAL COSTS (Rented Land)	-7.20
ANNUAL NET RETURNS PER ACRE (Avg.)	-5.92
NET RETURN TO MANAGEMENT (Total Farm)	-3789.72

* Assumes landlord paying 2/5 of herbicide (18.78), 2/5 of insecticide (0.00), and 2/5 of fertilizer (5.54) per acre.

Table 5.11. Income, Returns, and Selected Costs by Cropping System.

	CROPPING SYSTEM								
INCOME & COSTS	CVCC	NTCC	RTCC	CVCS	NTCS	RTCS	CVSS	NTSS	RTSS
Gross Income	$121215	118639	118110	129471	132265	126838	114766	116040	113652
Variable Costs									
(Owned Land)	19906	21157	21557	16389	18943	19174	15176	18995	19295
(Rented Land)	35108	36362	37561	29910	33153	33847	27468	32614	33360
Fixed Costs									
(Owned Land)	17218	14889	15760	17346	15386	16379	16407	14599	15367
(Rented Land)	55856	49701	51587	58468	54676	55473	52160	48297	49420
Total Cost	128087	122108	126465	122114	122158	124873	111211	114505	117442
NET RETURN	-6873	-3470	-8355	7357	10107	1965	3555	1536	-3790
Labor	2765	1773	2106	2691	1866	1866	2368	1709	1709
Fuel/Oil	2672	1391	1663	2686	1527	1520	2399	1376	1376
Chemical Cost	18362	23917	23027	13632	22694	22173	17638	30208	30054
SUBTOTAL	23798	27081	26796	19010	26087	25558	22406	33293	33140
Fertilizer	19488	19488	19488	14179	14179	14179	8870	8870	8870
SUBTOTAL	43286	46569	46284	33189	40266	39737	31276	42164	42010
Repair	8570	7238	8768	8624	7555	8803	7667	6733	7821
Depreciation	15072	11482	12819	15302	12294	13811	13779	10995	12179
Interest	17807	14317	15797	17410	14704	16333	15763	13514	14786
SUBTOTAL	84735	79605	83668	74525	74820	78685	68485	73405	76795
TOTAL	84735	79605	83668	74525	74820	78685	68485	73405	76795

for this system, but fertilizer, repair, depreciation, and interest costs were low enough to provide the third highest average net return.

It was not unexpected that the systems incorporating a corn - soybean rotation had the two highest gross incomes. Historically, corn yields following soybeans have been significantly higher than continuous corn yields. Raney et al. (1985) found that corn after soybean yields, on average, were 22 bushels per acre higher than continuous corn yields in a four year study done in Northcentral Kansas. In this study, corn yields in the corn - soybean rotation systems were significantly higher than corn yields in the continuous corn systems (See Appendix H). Actual Powhattan yield data are presented in Appendix D.

The fourth highest average net return of $1965 was achieved with the ridge-till corn - soybean system (RTCS). Gross income was $12072 higher than the CVSS system, but higher chemical, fertilizer, and machinery costs more than made up the difference in gross income between the two systems.

No-till continuous soybeans (NTSS) had the fifth highest net return of $1536. Gross income was low with chemical costs the highest of all systems. These chemical costs offset savings in fertilizer, labor, fuel, and machinery costs for this system.

The no-till continuous corn system (NTCC) had a negative net income, ranking sixth among the systems. Gross income was relatively low and had high fertilizer costs due to the requirements of the continuous rotation of corn.

A similar situation exists for the ridge-till continuous soybean (RTSS) system, with a net return ranking of seventh. A low gross income along with high chemical costs caused net return to be a negative number (-$3790).

The conventional-till continuous corn system (CVCC) had a net return of -$6873. Total costs, including fertilizer and machinery, were highest for this system.

The ridge-till continuous corn (RTCC) system had the largest loss of all (-$8355). High machinery and chemical costs combined to give this system the second largest total costs, while gross income was sixth lowest of the nine systems.

The systems that included the corn - soybean rotation, regardless of tillage method, showed the highest gross incomes and average net returns. Corn yields for these systems were significantly higher which has come to be expected from the corn after soybean rotation (See Appendices D and H).

Costs for the corn - soybean systems were also on the lower end of the scale since soil insecticides are not needed in this rotation, and only one-half of the acres (corn acres) need the relatively expensive nitrogen fertilizer application. These reasons also affected the net returns of the continuous soybean systems. No insecticide or nitrogen fertilizer application is needed which results in considerable cost savings. The continuous corn systems are in the last group of systems ranked by average net return. Insecticides and nitrogen fertilizers were needed for all continuous corn acres which added significantly to total costs.

Figure 5.1 provides a summary of gross returns, total variable and total fixed costs, and net return to management for all cropping systems.

Figure 5.1 Returns and Costs

by Cropping System

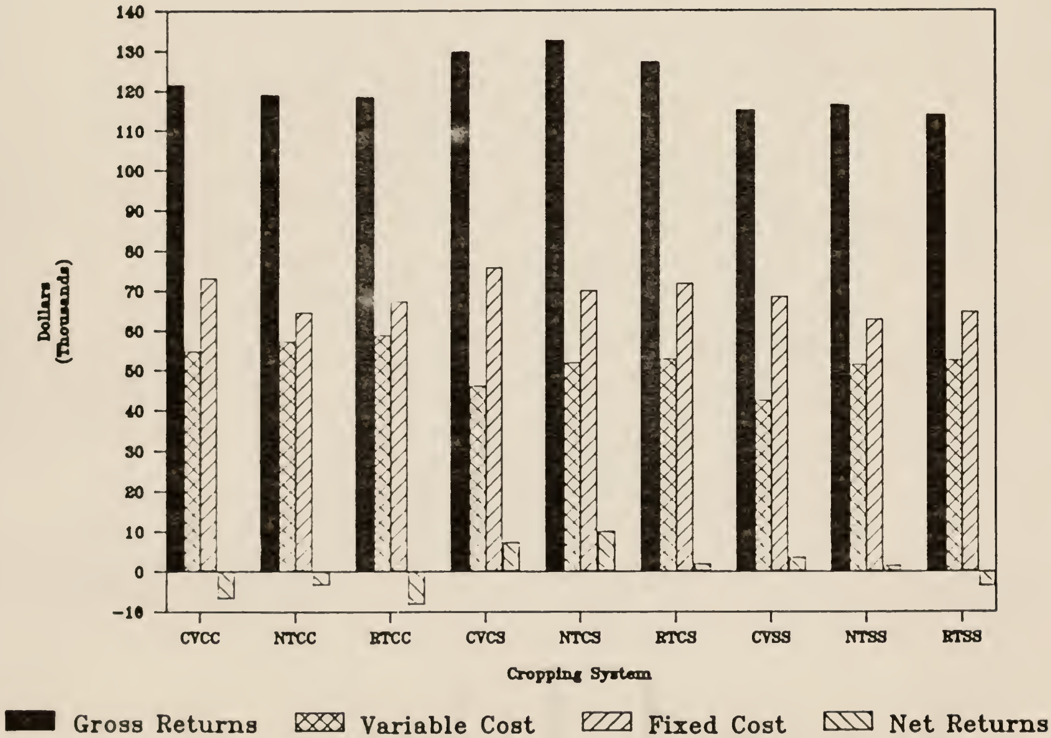
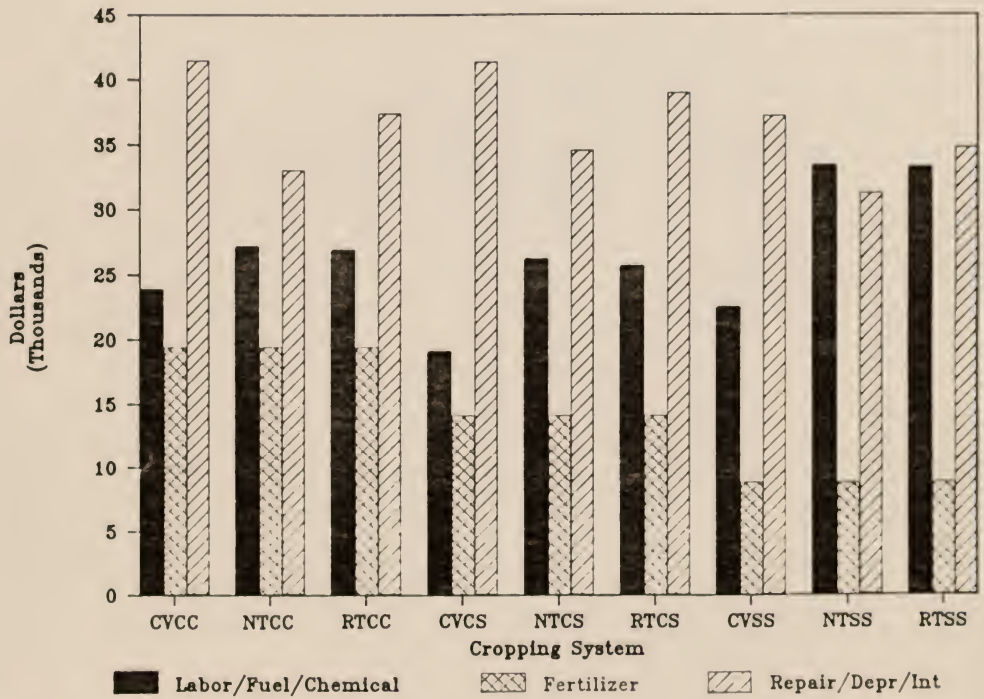


Figure 5.2 Selected Costs by Tillage System



A presentation of labor/fuel/chemical, fertilizer, and repair/depreciation/interest costs for all systems is also provided in figure 5.2.

Real estate taxes and interest on land are uniform for all systems. Depreciation, interest, and insurance and housing costs for machinery vary according to the machinery complement required for each system. Share rents for rented acres are calculated using gross return per acre and thus vary between systems.

RISK ANALYSIS

Traditional analysis of decision making situations has been divided into two classes: business risk and financial risk (Boehlje and Eidman, 1984). This study examines only business risk and uncertainty. Business risk and uncertainty are inherent in the firm independent of how it is financed. The major sources of business risk and uncertainty for a production unit are price and yield uncertainty. Prices are a function of commodity supply and demand, and are largely beyond the control of the individual producer. Yield variability results from differing crop management practices as well as weather, insect, and disease problems.

Yield, price, and net return variability of each system is examined to estimate the differences in risk associated with each cropping system. Standard deviation and coefficient of variation statistics are used in this study to compare yield and price variability.

Coefficient of variation is used to compare standard deviations when probability distributions have different expected values. The standard deviation is divided by the mean in order to obtain the coefficient of variation. Small coefficients of variation show that the distribution has less variability in relation to its expected value. Thus a lower risk per dollar of expected return exists.

YIELD AND PRICE VARIABILITY ANALYSIS

Table 5.12 contains the results of the yield and price variability analysis. Corn yield averages over the ten year study period ranged from 71.5 to 85.4 bushels per acre depending upon the tillage and crop rotation system. Analysis of variance procedures found no significant differences between system yields at the $\sigma = 0.05$ level. An additional method of measuring variation is provided by Fisher's LSD. This test provides the least significant difference between any two pair of means in a given experiment with significance of $(1-\sigma)\%$. The least significant difference for corn yield was 36.6 bushels per acre. This means that the corn yields of any two cropping systems must differ by more than 36.6 bushels per acre to indicate a statistical difference. The LSD for corn yields was quite high in this study due to the two drought years that had the equivalent of very low yields. Coefficient of variation was lowest for the ridge-till corn - soybean (RTCS) system and highest for the conventional-till continuous corn (CVCC) system.

Soybean yield averages over the study period ranged from 28.6 to 31.0 bushels per acre depending upon the tillage and crop rotation system. Analysis of variance procedures found no significant differences between system yields at the $\sigma = 0.05$ level. The least significant difference for soybeans was 9.2 bushels per acre as provided by Fisher's LSD. The ridge-till corn - soybean (RTCS) system had the lowest

Table 5.12 Yield, Price, and Net Return Variability by Cropping System from 1975 to 1984.

	CROPPING SYSTEM								
	CVCC	NTCC	RTCC	CVCS	NTCS	RTCS	CVSS	NTSS	RTSS
YIELDS (bu/acre)									
Corn									
Mean	73.4	71.9	71.5	83.5	85.4	82.8			
Std Dev	41.9	38.0	40.2	43.8	45.6	42.7			
Cof Var	57.10	52.85	56.25	52.48	53.36	51.60			
LSD	36.6	36.6	36.6	36.6	36.6	36.6			
Soybean									
Mean				30.4	31.0	29.4	28.8	29.2	28.6
Std Dev				10.0	10.6	9.6	10.8	10.6	9.7
Cof Var				32.95	34.11	32.62	37.31	36.45	33.91
LSD				9.2	9.2	9.2	9.2	9.2	9.2
PRICES (Dollars)									
Corn									
Mean	$2.58	2.58	2.58	2.58	2.58	2.58			
Std Dev	$0.44	0.44	0.44	0.44	0.44	0.44			
Cof Var	17.2	17.2	17.2	17.2	17.2	17.2			
Soybean									
Mean				$6.22	6.22	6.22	6.22	6.22	6.22
Std Dev				$0.93	0.93	0.93	0.93	0.93	0.93
Cof Var				14.9	14.9	14.9	14.9	14.9	14.9
NET RETURNS (1985 Dollars)									
Mean	$-11741	-7836	-13069	7349	12770	-3123	1083	-1124	-6059
Std Dev	$44219	40416	42407	62849	67668	61207	26141	24866	23384
Cof Var				855.2	529.9		2414.3		

coefficient of variation while the conventional tillage continuous soybean (CVSS) system recorded the highest. Coefficients of variation ranged from 51.60 to 57.10 for corn yields and from 32.62 to 37.31 for soybean yields. This indicates that corn yields were more variable than soybean yields over the study period relative to their respective means. Soybean yields were not reduced as much proportionally as corn yields by the 1980 and 1983 droughts.

Corn prices averaged $2.58/bu. and soybean prices averaged $6.22/bu. for the ten year period. The coefficient of variation for corn prices was 17.2 compared to 14.9 for soybean prices. This indicates that corn prices were more variable relative to their respective means than were soybean prices for the period 1975 to 1984.

NET RETURN VARIABILITY ANALYSIS

Average net returns over the 10 year test period ranged from $12770 to $-13069 with only three of the nine systems (CVCS, NTCS, and CVSS) having positive average net returns (Table 5.13). Returns for each year were calculated by subtracting 1985 costs of production from gross incomes (which were calculated using actual 1974-84 yield and price information). Thus actual net returns are understated for the ten year period since no allowance is made for deflated input costs during the earlier years of the study.

The no-till corn - soybean (NTCS) system had the highest average net return ($12770) of all systems over the test period. The ridge-till continuous corn (RTCC) system had the lowest average net return ($-13069). Coefficient of variation statistics indicate that average net

Table 5.13 Yearly Net Returns by Cropping System

YEAR	CVCC	NTCC	RTCC	CVCS	NTCS	RTCS	CVSS	NTSS	RTSS
1975	-43154	-26516	-34208	-29782	-31318	-38546	-13383	-14327	-17718
1976	-39302	-28471	-39546	-38160	-27184	-35050	-14484	-15910	-24653
1977	3663	-9234	61	42680	43076	20331	30854	29489	20642
1978	-3873	2011	-12118	-10919	-11955	-24922	-14821	-14696	-16472
1979	58030	54882	58339	94281	108326	77186	19629	17516	9791
1980	-68288	-59337	-70153	-47434	-52389	-60841	14984	3688	11920
1981	44995	48517	45747	87127	107224	80670	33488	29210	20762
1982	25803	28141	11592	82070	90501	73877	22596	21984	10630
1983	-59474	-52240	-58875	-71667	-56304	-81470	-38767	-39183	-42076
1984	-35813	-36111	-31526	-34702	-42273	-42465	-29269	-29007	-33419
MEAN	-11741	-7836	-13069	7349	12770	-3123	1083	-1124	-6059
STD. DEV.	44218.7	40415.7	42407.0	62848.8	67668.4	61207.0	26141.1	24866.4	23383.9
COF.VAR.				855.2	529.9		2414.3		
MIN	-68288	-59337	-70153	-71667	-56304	-81470	-38767	-39183	-42076
MAX	58030	54882	58339	94281	108326	80670	33488	29489	20762
TOTAL NEG.	-249905	-211910	-246426	-232664	-221424	-283294	-110724	-113124	-134338
TOTAL NO. NEG. YEARS	6	6	6	6	6	6	5	5	5

returns were less variable for the NTCS system than for any other (Table 5.13). The NTCS system also had the highest one-year net return of $108326.

Conventional-till continuous soybeans exhibited the smallest one-year loss of $-38767. Total losses for the ten year period were also smallest for the CVSS system. The greatest single year loss of $-71677 was found in the conventional-till corn - soybean system (CVCS), while the ridge-till corn - soybean (RTCS) system had the largest total losses of $-283294. The total number of years that each system exhibited losses is also provided in Table 5.13.

STOCHASTIC DOMINANCE ANALYSIS

Stochastic dominance analysis is a method of selecting efficient strategies through comparisons of cumulative probability distributions of possible incomes for each strategy. Stochastic dominance is more flexible than mean variance (E-V) analysis since it does not require the underlying distribution to have a normal distribution. In this study, stochastic dominance with respect to a function (SDWRF) is used in addition to first degree stochastic dominance (FSD) and second degree stochastic dominance (SSD) criteria because it is more flexible and has greater discriminating power than both FSD and SSD. Also, the specification of the decision maker's utility function is not required for SDWRF.

SDWRF orders choices for decision makers facing uncertainty by setting upper and lower bounds to define an interval using the Pratt absolute risk aversion function, R(x).

Table 5.14 Stochastic Dominance Analysis Results by Cropping System[1]

	$R_1(x)$	$R_2(x)$	Cropping Systems								
			CVCC	NTCC	RTCC	CVCS	NTCS	RTCS	CVSS	NTSS	RTSS
FSD	-0.000923	+0.000923	x	x	x	x	x		x	x	
SSD	0.0	0.000923					x		x		
SDWRF	-0.00005	-0.00001					x				
	-0.00001	0.0					x				
	0.0	0.00001					x		x		
	-0.00001	0.00001					x		x		
	0.00001	0.00005							x		
	0.00005	0.0001							x		
	0.0001	0.001							x		

[1] Systems denoted by x are in the efficient set.

Table 5.15 Stochastic Dominance Analysis Results by Rotation[1] (Conventional Tillage)

	$R_1(x)$	$R_2(x)$	Cropping Systems		
			CVCC	CVCS	CVSS
FSD	-0.001061	+0.001061	x	x	x
SSD	0.0	0.001061		x	x
SDWRF	-0.00005	-0.00001		x	
	-0.00001	0.0		x	
	0.0	0.00001		x	x
	-0.00001	0.00001		x	x
	0.00001	0.00005			x
	0.00005	0.0001			x
	0.0001	0.001			x

[1] Systems denoted by x are in the efficient set.

Table 5.16 Stochastic Dominance Analysis Results by Rotation[1] (No-Till)

	$R_1(x)$	$R_2(x)$	NTCC	Cropping System NTCS	NTSS
FSD	-0.000923	+0.000923	x	x	x
SSD	0.0	0.000923		x	x
SDWRF	-0.00005	-0.00001		x	
	-0.00001	0.0		x	
	0.0	0.00001		x	x
	-0.00001	0.00001		x	x
	0.00001	0.00005			x
	0.00005	0.0001			x
	0.0001	0.001			x

[1] Systems denoted by x are in the efficient set.

Table 5.17 Stochastic Dominance Analysis Results by Rotation[1] (Ridge-till)

	$R_1(x)$	$R_2(x)$	RTCC	Cropping Systems RTCS	RTSS
FSD	-0.001227	+0.001227	x	x	x
SSD	0.0	0.001227		x	x
SDWRF	-0.00005	-0.00001		x	
	-0.00001	0.0		x	
	0.0	0.00001		x	x
	-0.00001	0.00001		x	x
	0.00001	0.00005			x
	0.00005	0.0001			x
	0.0001	0.001			x

[1] Systems denoted by x are in the efficient set.

Table 5.18 Stochastic Dominance Analysis Results by Tillage System[1] (Continuous corn rotation)

	$R_1(x)$	$R_2(x)$	Tillage Systems		
			CVCC	NTCC	RTCC
FSD	-0.001425	+0.001425	x	x	x
SSD	0.0	0.001425		x	
SDWRF	-0.00005	-0.00001	x	x	
	-0.00001	0.0		x	
	0.0	0.00001		x	
	-0.00001	0.00001		x	
	0.00001	0.00005		x	
	0.00005	0.0001		x	
	0.0001	0.001		x	

[1] Systems denoted by x are in the efficient set.

Table 5.19 Stochastic Dominance Analysis Results by Tillage System[1] (Corn - soybean rotation)

	$R_1(x)$	$R_2(x)$	Tillage Systems		
			CVCS	NTCS	RTCS
FSD	-0.000923	+0.000923	x	x	
SSD	0.0	0.000923		x	
SDWRF	-0.00005	-0.00001		x	
	-0.00001	0.0		x	
	0.0	0.00001		x	
	-0.00001	0.00001		x	
	0.00001	0.00005		x	
	0.00005	0.0001		x	
	0.0001	0.001		x	

[1] Systems denoted by x are in the efficient set.

Table 5.20 Stochastic Dominance Analysis Results by Tillage System[1] (Continuous soybean rotation)

	$R_1(x)$	R2(x)	CVSS	NTSS (Tillage Systems)	RTSS
FSD	-0.002377	+0.002377	x	x	
SSD	0.0	0.002377	x		
SDWRF	-0.00005	-0.00001	x		
	-0.00001	0.0	x		
	0.0	0.00001	x		
	-0.00001	0.00001	x		
	0.00001	0.00005	x		
	0.00005	0.0001	x		
	0.0001	0.001	x		

[1] Systems denoted by x are in the efficient set.

R(x) is defined by Pratt as:

$$R(x) = -U''(x)/U'(x)$$

which is the ratio of the derivatives of the decision maker's utility function U(x). The SDWRF classes of utility functions can be established by using risk preference intervals bounded by a lower risk aversion coefficient $R_1(x)$ and an upper risk aversion coefficient $R_2(x)$.

Seven risk aversion coefficient intervals were used for the SDWRF analysis (Tables 5.14 - 5.20). These intervals were arbitrarily assumed for this study. King and Robison (1981) suggested that most intervals should be established between the range of -0.0001 to 0.001. Risk neutral behavior would generally be exhibited within the range of -0.00001 and 0.00001. Individuals above 0.00001 would exhibit more risk-averse behavior, with those below -0.00001 exhibiting risk-seeking behavior. An optimal control algorithm developed by Raskin, Goh, and Cochran (1986) was used to find solutions to the risk aversion intervals.

Stochastic dominance analysis was used to find the first degree (FSD), second degree (SSD), and stochastic dominance with respect to a function (SDWRF) efficient sets (Table 5.14). Ridge-till corn - soybean rotation (RTCS) and ridge-till continuous soybeans (RTSS) were dominated by all other systems using first degree criteria. The no-till corn - soybean rotation (NTCS) and conventional-till continuous soybeans (CVSS) systems were second degree efficient. Analysis using SDWRF determined that the no-till corn - soybean rotation (NTCS) was preferred by risk-seeking managers while risk-averse managers would prefer the conventional-till continuous soybean (CVSS) system.

Stochastic dominance analysis was also performed to determine FSD, SSD, and SDWRF efficient sets among tillage systems within crop rotations and crop rotations within tillage systems. Among the conventional tillage systems no rotation was dominated by first degree criteria while the conventional corn - soybean (CVCS) and continuous soybean (CVSS) rotations were second degree efficient (Table 5.15). Risk seeking managers would prefer the CVCS system while risk-averse managers would prefer the CVSS system according to SDWRF analysis.

An analysis of the no-till systems determined that no rotation was dominated by FSD criteria (Table 5.16). The no-till corn - soybean (NTCS) and continuous soybean (NTSS) systems were second degree efficient. SDWRF analysis determined that risk-seeking managers would prefer the NTCS system while risk-averse individuals would prefer the NTSS system.

The ridge-till systems were also compared using stochastic dominance analysis (Table 5.17). No rotation was dominant using first degree criteria. The ridge-till corn - soybean (RTCS) and continuous soybean (RTSS) systems were found to be second degree efficient. SDWRF analysis determined that risk-seeking managers would prefer the RTCS system while risk-averse managers would prefer the RTSS system.

The risk factors of the three tillage systems were also examined within each cropping rotation. FSD analysis determined that no tillage system was dominant within the continuous corn rotation (Table 5.18). The no-till continuous corn (NTCC) was found to be second degree efficient. SDWRF analysis determined that risk-seeking individuals would prefer either the CVCC or NTCC system, while risk-averse managers would prefer the NTCC system.

The conventional corn - soybean (CVCS) and no-till corn - soybean (NTCS) rotations were dominant using first degree criteria when tillage systems were analyzed within the corn - soybean rotations (Table 5.19). The NTCS system was also found to be second degree efficient. SDWRF analysis determined that the NTCS system would be preferred by either risk-seeking or risk-averse managers.

Risk analysis of the three tillage systems within the continuous soybean rotation framework found that the conventional continuous (CVSS) and no-till continuous (NTSS) soybean systems were dominant using FSD criteria (Table 5.20). The CVSS system was determined to be second degree efficient. SDWRF analysis determined that the CVSS system would be preferred by either risk-seeking or risk-averse individuals.

SENSITIVITY ANALYSIS

Sensitivity analysis was used to identify the magnitude of the parallel shift of the dominant distribution (CVSS) that is necessary to eliminate its dominance and produce an efficient set which would contain both the previously dominant distribution and the specified alternative.

The moderately risk averse interval (0.00001-0.00005) shows particular sensitivity to production costs or yield differences between the no-till continuous soybean (NTSS) and the no-till corn - soybean (NTCS) systems and the dominant CVSS system (Table 5.21). Lowering the CVSS cumulative probability distribution by a parallel shift of $825 would result in CVSS no longer dominating NTSS. Dividing this amount

($825) by the number of acres in the case farm (640) results in a $1.29 decline per acre. Dividing $1.29 by the average price of soybeans ($6.22) results in a 0.21 bushel per acre decrease in the yield of CVSS for NTSS to be the dominant system. A CVSS yield decrease of 0.75 bushels per acre is necessary for the NTCS system to dominate the CVSS system. The other systems are compared in Table 5.21.

The strongly risk averse interval (0.00005-0.0001) is also very sensitive to production cost or yield variations between the CVSS and NTSS systems (Table 5.22). A 0.09 bushel per acre yield difference will allow the NTSS system to dominate. The remaining systems are compared in Table 5.22. Standard deviations were used in each table to compare the respective net returns of these closely ranked systems.

Table 5.21 Sensitivity Analysis for the Interval 0.00001-0.00005

Dominant System		Compared System	Decrease In Net Return Of Dominant System	Cost Per Acre	Bushels Per Acre (Soybeans)
CVSS	<-->	NTSS	825	1.29	0.21
CVSS	<-->	NTCS	3000	4.69	0.75
CVSS	<-->	RTSS	4825	7.54	1.21
CVSS	<-->	RTCC	5425	8.48	1.36
CVSS	<-->	CVCS	6600	10.31	3.20
CVSS	<-->	NTCC	12750	19.92	4.08
CVSS	<-->	RTCS	16250	25.39	4.53
CVSS	<-->	CVCC	18025	28.16	4.68
Variation Due To Soybean Yields (Std. Dev.)			36620	57.22	9.2

Table 5.22 Sensitivity Analysis for the Interval 0.00005-0.0001

Dominant System		Compared System	Decrease In Net Return Of Dominant System	Cost Per Acre	Bushels Per Acre (Soybeans)
CVSS	<-->	NTSS	375	.59	.09
CVSS	<-->	RTSS	4025	6.29	1.01
CVSS	<-->	RTCC	15025	23.48	3.77
CVSS	<-->	NTCS	18975	29.65	4.77
CVSS	<-->	NTCC	19400	30.31	4.87
CVSS	<-->	CVCS	24800	38.75	6.23
CVSS	<-->	CVCC	27325	42.70	6.86
CVSS	<-->	RTCS	34175	53.40	8.59
Variation Due To Soybean Yields (Std. Dev.)			36620	57.22	9.2

CHAPTER SIX

SUMMARY AND CONCLUSIONS

Conservation tillage continues to be an important tool for the reduction of soil erosion throughout the United States. At the same time reduced tillage systems can potentially increase net incomes for crop producers by lowering input costs with no decreases and occasional increases in yield levels. This study evaluates the economic potential and associated yield and net income risk of conventional and conservation tillage systems for corn and soybean producers in Northeast Kansas.

A representative 640 acre case farm is established to provide comparisons of income potential and variability of conventional-till, no-till, and ridge-till cropping systems in Northeast Kansas. Cornbelt Experiment Station yields were utilized in the study with the assumption that crop producers could realistically achieve similar yields. Crop input levels were determined by agronomists and Experiment Station personnel with that criterion in mind.

An equipment complement was selected to meet the optimal tillage and planting requirements of the nine cropping systems. Variable and fixed costs were used to calculate net returns to management for each system. Analysis of variance of yield and price provided estimates of the differences between cropping systems while stochastic dominance with respect to a function was used in discriminating between the net returns of the nine systems.

RESULTS AND CONCLUSIONS

An analysis of net returns found the no-till corn - soybean rotation (NTCS) to have a higher average return than the second place conventional-till corn - soybean rotation (CVCS). The NTCS system also has the highest standard deviation but the lowest coefficient of variation of the nine systems.

Stochastic dominance with respect to a function determined that risk averse managers would prefer the conventional-till continuous soybean system (CVSS) over all others. Although the mean yield of this system was low, the standard deviation was also low. A producer would not expect large variations in net income when utilizing this cropping system.

Risk seeking individuals would prefer the NTCS system due to the highest average net return. SDWRF did not differentiate between the NTCS and CVSS systems for the risk neutral manager. Sensitivity analysis found differences in returns between the two systems to be very sensitive to slight variations in yield.

Stochastic dominance analysis was also performed to determine SDWRF efficient sets among tillage systems and crop rotations. The no-till system was the preferred tillage system within the continuous corn and corn - soybean rotation systems regardless of whether the manager was risk-seeking or risk-averse. The conventional tillage system was preferred within the continuous soybean system by either risk-seeking ro risk-averse individuals. Also, SDWRF determined that risk seeking managers would prefer a corn - soybean crop rotation while risk averse individuals would prefer a continuous soybean crop rotation. This was the case regardless of tillage system selected.

Costs tended to be lowest for the no-till systems. The ridge-till systems suffered from high machinery and chemical costs with yields not significantly higher than the no-till or conventional-till systems.

LIMITATIONS OF STUDY

Two major limitations exist for this study. The first limitation concerns the case farm determination. Since no "average" farm actually exists the selection of a machinery complement to accompany this case farm is difficult. Producers vary greatly in their tillage constraints, practices, and machinery preferences.

The second limitation is whether the cropping input levels used in this study accurately reflect the current "state of the art" in crop production practices. Although the experiment station yields used in this study compare favorably with actual farm yields in the area, herbicide formulations and application methods have been improved since this tillage yield study began in 1975. Changes in input levels may thus alter economic rankings of the cropping systems.

Careful consideration must also be given to variation in management expertise on a farm by farm basis. Different soil types could also influence the applicability of this study to a given area.

FUTURE RESEARCH NEEDS

The limitations of this study suggest the need for further research on the subject of conservation tillage. A more accurate determination of machinery complements, along with updated input levels, would improve the analysis. Incorporation of long-term cost savings due to reduced soil erosion would also give a more accurate economic analysis of the various systems. The quantification of the long-run value of eroded soil may well be one of the more important additions to a continuing study of this subject. Sensitivity analysis of variable input costs may also allow more precise conclusions to be drawn from this study.

Incorporating various crop insurance programs into the analysis would influence the risk element and could provide new ordering by the stochastic dominance procedures. Cropping system constraints placed upon the farm manager by participation in government programs, as well as the economic incentives offered, could also be addressed to supply a more complete picture of the economics of crop production in Northeast Kansas in the 1980's.

APPENDICES

Appendix A

Appendix A contains the machinery selection worksheets for the conventional tillage systems (Schrock, 1976). The primary tillage operation (discing) was the critical factor in determining the size of the 160 horsepower tractor. Additional secondary tillage (discing) was required by the 131 horsepower tractor. Two tractors were also needed for planting and cultivating operations.

Tables A-1 to A-9 represent the worksheets used to calculate tractor and implement sizes.

Table A-1 Machinery Selection Worksheet For Conventional-Till Systems

Identify the Critical Job	
Description	Shredding
Amount	320 Acres
Estimate the Time Available	
Desired Period - April 1 to April 17	17 Days
Percentage of Time Available for Work . . .	23.3%
Available Working Days	4.0 Days
Hours per Day	12 Hours
Total Running Time	48.0 Hours
Size the Machinery to do the Job	
Field Capacity Needed	5.7 A/Hr.
Speed	5.0 MPH
Field Efficiency	80.0%
Required Width	11.8 Feet
Estimate the Power Requirements	
Required Width	12.0 Feet
PTO HP per Foot of Width	10 HP/Ft.
Required PTO Horsepower	120 HP

12 Foot Shredder
131 HP Tractor

Table A-2 Machinery Selection Worksheet For Conventional-Till Systems

Identify the Critical Job	
Description	1st Discing
Amount	640 Acres
Estimate the Time Available	
Desired Period - April 1 to April 24	24 Days
Percentage of Time Available for Work . . .	23.3%
Available Working Days	5.6 Days
Hours per Day	12 Hours
Total Running Time	67.2 Hours
Size the Machinery to do the Job	
Field Capacity Needed	9.8 A/Hr.
Speed	5.5 MPH
Field Efficiency	85.0%
Required Width	17.3 Feet
Estimate the Power Requirements	
Required Width	18 Feet
PTO HP per Foot of Width	7.5 HP/Ft.
Required PTO Horsepower	135 HP

18 Foot Disc
160 HP Tractor

Table A-3 Machinery Selection Worksheet For Conventional-Till Systems

Identify the Critical Job	
Description	2nd Discing
Amount	320 Acres
Estimate the Time Available	
Desired Period - April 18 to April 29 . . .	12 Days
Percentage of Time Available for Work . . .	26.7%
Available Working Days	3.2 Days
Hours per Day	12 Hours
Total Running Time	38.4 Hours
Size the Machinery to do the Job	
Field Capacity Needed	8.5 A/Hr.
Speed	5.5 MPH
Field Efficiency	85.0%
Required Width	14.9 Feet
Estimate the Power Requirements	
Required Width	15 Feet
PTO HP per Foot of Width	7.5 HP/Ft.
Required PTO Horsepower	112 HP

15 Foot Disc
131 HP Tractor

Table A-4 Machinery Selection Worksheet For Conventional-Till Systems

Identify the Critical Job	
Description	Field Cultivating
Amount	640 Acres
Estimate the Time Available	
Desired Period - April 25 to May 9	15 Days
Percentage of Time Available for Work . . .	26.7%
Available Working Days	4.0 Days
Hours per Day	12 Hours
Total Running Time	48.0 Hours
Size the Machinery to do the Job	
Field Capacity Needed	12.3 A/Hr.
Speed	5.5 MPH
Field Efficiency	85.0%
Required Width	23.9 Feet
Estimate the Power Requirements	
Required Width	24 Feet
PTO HP per Foot of Width	5 HP/Ft.
Required PTO Horsepower	120 HP

24 Foot Field Cultivator
160 HP Tractor

Table A-5 Machinery Selection Worksheet For Conventional-Till Systems

Identify the Critical Job	
Description	Planting
Amount	414 Acres
Estimate the Time Available	
Desired Period - April 30 to May 22	23 Days
Percentage of Time Available for Work	23.3%
Available Working Days	5.4 Days
Hours per Day	12 Hours

Total Running Time	64.8 Hours
Size the Machinery to do the Job	
Field Capacity Needed	6.6 A/Hr.
Speed	5.0 MPH
Field Efficiency	60.0%
Required Width	18.15 Feet
Estimate the Power Requirements	
Required Width	18 Feet
Draft per Foot of Width	350 Lb.
Speed	5 MPH
Required Drawbar Horsepower	84 HP
Required PTO Horsepower	92 HP

18 Foot Planter
131 HP Tractor

Table A-6 Machinery Selection Worksheet For Conventional-Till Systems

Identify the Critical Job	
Description	Planting
Amount	226 Acres
Estimate the Time Available	
Desired Period - May 10 to May 22	13 Days
Percentage of Time Available for Work . . .	23.3%
Available Working Days	3.0 Days
Hours per Day	12 Hours
Total Running Time	36.0 Hours
Size the Machinery to do the Job	
Field Capacity Needed	6.6 A/Hr.
Speed	5.0 MPH
Field Efficiency	60.0%
Required Width	18.15 Feet
Estimate the Power Requirements	
Required Width	18 Feet
Draft per Foot of Width	350 Lb.
Speed	5 MPH
Required Drawbar Horsepower	84 HP
Required PTO Horsepower	92 HP

18 Foot Planter
160 HP Tractor

Table A-7 Machinery Selection Worksheet For Conventional-Till Systems

Identify the Critical Job	
Description	Cultivating
Amount	640 Acres
Estimate the Time Available	
Desired Period - June 5 to June 18	14 Days
Percentage of Time Available for Work . . .	27.3%
Available Working Days	3.8 Days
Hours per Day	12 Hours

Total Running Time	45.6 Hours
Size the Machinery to do the Job	
Field Capacity Needed	12.8 A/Hr.
Speed	4.5 MPH
Field Efficiency	70%
Required Width	33.5 Feet
Estimate the Power Requirements	
Required Width	18 Feet
Draft per Foot of Width	120 Lb.
Speed	4.5 MPH
Required Drawbar Horsepower	26 HP
Required PTO Horsepower	29 HP

(2) 18 Foot Cultivators
131 HP Tractor
160 HP Tractor

Table A-8 Machinery Selection Worksheet For Conventional-Till Systems

Identify the Critical Job	
Description	Harvesting
Amount	640 Acres
Estimate the Time Available	
Desired Period - September 16 to October 31.	46 Days
Percentage of Time Available for Work . . .	30.0%
Available Working Days	13.8 Days
Hours per Day	7 Hours

Total Running Time	96.6 Hours
Size the Machinery to do the Job	
Field Capacity Needed	6.6 A/Hr.
Speed	4.0 MPH
Field Efficiency	70.0%
Required Width	19.5 Feet
Estimate the Power Requirements	
Required Width	20 Feet

20 Foot Platform
6 Row Corn head

Appendix B

Appendix B contains the machinery selection worksheets for the no-till systems (Schrock, 1976). The shredding operation was the determining factor in selecting a 131 horsepower tractor. An additional 60 horsepower tractor was needed to pull a second cultivator.

Tables B-1 to B-4 represent the worksheets used to calculate tractor and implement sizes.

Table B-1 Machinery Selection Worksheet For No-Till Systems

Identify the Critical Job	
Description	Shredding
Amount	160 Acres
Estimate the Time Available	
Desired Period - April 1 to April 10	10 Days
Percentage of Time Available for Work . . .	23.3%
Available Working Days	2.3 Days
Hours per Day	12 Hours

Total Running Time	27.6 Hours
Size the Machinery to do the Job	
Field Capacity Needed	5.7 A/Hr.
Speed	5.5 MPH
Field Efficiency	85.0%
Required Width	10.0 Feet
Estimate the Power Requirements	
Required Width	12 Feet
PTO HP per Foot of Width	10 HP/Ft.
PTO Horsepower	120 HP

12 Foot Shredder
131 HP Tractor

Table B-2 Machinery Selection Worksheet For No-Till Systems

Identify the Critical Job	
Description	Planting
Amount	640 Acres
Estimate the Time Available	
Desired Period - April 21 to May 22	32 Days
Percentage of Time Available for Work	23.3%
Available Working Days	7.5 Days
Hours per Day	12 Hours
Total Running Time	90 Hours
Size the Machinery to do the Job	
Field Capacity Needed	6.6 A/Hr.
Speed	5.0 MPH
Field Efficiency	60.0%
Required Width	18.15 Feet
Estimate the Power Requirements	
Required Width	18 Feet
Draft per Foot of Width	350 Lb.
Speed	5.0 MPH
Required Drawbar Horsepower	84 HP
Required PTO Horsepower	92 HP

18 Foot Planter
131 HP Tractor

Table B-3 Machinery Selection Worksheet For No-Till Systems

Identify the Critical Job	
Description	Cultivating
Amount	640 Acres
Estimate the Time Available	
Desired Period - June 1 to June 15	15 Days
Percentage of Time Available for Work . . .	26.7%
Available Working Days	4.0 Days
Hours per Day	12 Hours
Total Running Time	48.0 Hours
Size the Machinery to do the Job	
Field Capacity Needed	12.8 A/Hr.
Speed	4.5 MPH
Field Efficiency	70.0%
Required Width	33.5 Feet
Estimate the Power Requirements	
Required Width	18 Feet
Draft per Foot of Width	120 Lb.
Speed	4.5 MPH
Required Drawbar Horsepower	26 HP
Required PTO Horsepower	29 HP

(2) 18 Foot Cultivators
131 HP Tractor
60 HP Tractor

Table B-4 Machinery Selection Worksheet For No-Till Systems

Identify the Critical Job	
Description	Harvesting
Amount	640 Acres
Estimate the Time Available	
Desired Period - September 16 to October 31.	46 Days
Percentage of Time Available for Work	30.0%
Available Working Days	13.8 Days
Hours per Day	7 Hours
Total Running Time	96.6 Hours
Size the Machinery to do the Job	
Field Capacity Needed	6.6 A/Hr.
Speed	4.0 MPH
Field Efficiency	70.0%
Required Width	19.5 Feet
Estimate the Power Requirements	
Required Width	20 Feet

20 Foot Platform
6 Row Corn head

Appendix C

Appendix C contains machinery selection worksheets for the Ridge-Till systems (Schrock, 1976). The planting operation was the determining factor in selecting the 170 horsepower tractor. A additional 60 horsepower tractor was needed to pull the second cultivator.

Tables C-1 to C-5 represent the worksheets used to calculate tractor and implement sizes.

Table C-1 Machinery Selection Worksheet For Ridge-Till Systems

Identify the Critical Job	
Description	Shredding
Amount	320 Acres
Estimate the Time Available	
Desired Period - April 1 to April 17	17 Days
Percentage of Time Available for Work . . .	23.3%
Available Working Days	4.0 Days
Hours per Day	12 Hours
Total Running Time	48.0 Hours
Size the Machinery to do the Job	
Field Capacity Needed	5.7 A/Hr.
Speed	5.5 MPH
Field Efficiency	85.0%
Required Width	10.0 Feet
Estimate the Power Requirements	
Required Width	12 Feet
PTO HP per Foot of Width	10 HP/Ft.
PTO Horsepower	120 HP

12 Foot Shredder
170 HP Tractor

Table C-2 Machinery Selection Worksheet For Ridge-Till Systems

Identify the Critical Job	
Description	Field Cultivating
Amount	160 Acres
Estimate the Time Available	
Desired Period - April 18 to April 21 . . .	4.2 Days
Percentage of Time Available for Work . . .	23.3%
Available Working Days	.98 Days
Hours per Day	12 Hours

Total Running Time	11.8 Hours
Size the Machinery to do the Job	
Field Capacity Needed	12.3 A/Hr.
Speed	5.5 MPH
Field Efficiency	85.0%
Required Width	23.9 Feet
Estimate the Power Requirements	
Required Width	24 Feet
PTO HP per Foot of Width	5 HP/Ft.
Required PTO Horsepower	120 HP

24 Foot Field Cultivator
170 HP Tractor

Table C-3 Machinery Selection Worksheet For Ridge-Till Systems

Identify the Critical Job	
Description	Planting
Amount	640 Acres
Estimate the Time Available	
Desired Period - April 22 to May 23	32 Days
Percentage of Time Available for Work	23.3%
Available Working Days	7.5 Days
Hours per Day	12 Hours
Total Running Time	90 Hours
Size the Machinery to do the Job	
Field Capacity Needed	6.6 A/Hr.
Speed	5.0 MPH
Field Efficiency	60.0%
Required Width	18.15 Feet
Estimate the Power Requirements	
Required Width	18 Feet
Draft per Foot of Width	450 Lb.
Speed	5.0 MPH
Required Drawbar Horsepower	108 HP
Required PTO Horsepower	119 HP

18 Foot Planter
170 HP Tractor

Table C-4 Machinery Selection Worksheet For No-Till Systems

Identify the Critical Job	
Description	Cultivating
Amount	640 Acres
Estimate the Time Available	
Desired Period - June 1 to June 15	15 Days
Percentage of Time Available for Work . . .	26.7%
Available Working Days	4.0 Days
Hours per Day	12 Hours
Total Running Time	48.0 Hours
Size the Machinery to do the Job	
Field Capacity Needed	12.8 A/Hr.
Speed	4.5 MPH
Field Efficiency	70.0%
Required Width	33.5 Feet
Estimate the Power Requirements	
Required Width	18 Feet
Draft per Foot of Width	120 Lb.
Speed	4.5 MPH
Required Drawbar Horsepower	26 HP
Required PTO Horsepower	29 HP

(2) 18 Foot Cultivators
170 HP Tractor
60 HP Tractor

Table C-5 Machinery Selection Worksheet For No-Till Systems

Identify the Critical Job	
Description	Harvesting
Amount	640 Acres
Estimate the Time Available	
Desired Period - September 16 to October 31.	46 Days
Percentage of Time Available for Work . . .	30.0%
Available Working Days	13.8 Days
Hours per Day	7 Hours

Total Running Time	96.6 Hours
Size the Machinery to do the Job	
Field Capacity Needed	6.6 A/Hr.
Speed	4.0 MPH
Field Efficiency	70.0%
Required Width	19.5 Feet
Estimate the Power Requirements	
Required Width	20 Feet

20 Foot Platform
6 Row Corn head

Appendix D

List prices for tractors and implements were the average of prices of two major manufacturers obtained from Northeast Kansas farm machinery dealers. Crop input prices were obtained from local suppliers and USDA. Crop prices are the average annual prices for the North East crop reporting district of Kansas. Crop yields are actual Cornbelt Experiment Field data.

Table D.1 Machinery Prices

Equipment	Conv.	Ridge	No-Till	Price
2WD Tractor, 60		X	X	$22,215
2WD Tractor, 131 HP	X		X	52,576
2WD Tractor, 160 HP	X			64,137
2WD Tractor, 170 HP		X		66,659
Shredder, 12 Ft.	X	X	X	4,464
Disc, 15 Ft.	X			6,498
Disc, 18 Ft.	X			10,736
Field Cultivator, 24 Ft.	X			9,513
Planter, 18 Ft. 6 Row w/ herb. attachment	X	X	X	14,904
Planter Attachment: No-Till			X	1,783
Planter Attachment: Ridge-Till		X		5,432
Row crop Cult. 6 Row	X		X	3,924
Ridge-Till Cult. 6 Row		X		8,167
Combine	X	X	X	93,517
Platform, 20 Ft.	X	X	X	11,142
Cornhead, 6 Row	X	X	X	19,349

Table D.2 Input Costs

Product	Average Cost
FERTILIZERS:	
Anhydrous Ammonia	$230.67/ton
Liquid 10-34-0	235.67/ton
HERBICIDES:	
Alachlor 4EC	23.00/gal
Atrazine 4L	9.45/gal
Glyphosate 4EC	87.60/gal
Metalachlor 8E	54.20/gal
Metribuzin 4L	110.00/gal
Paraquat 2EC	55.00/gal
2,4-D LVE 4EC	11.40/gal
INSECTICIDES:	
Chlorpyrifos 15G	1.56/lb.

Table D.3 Season Average Prices - Kansas Northeast District

Year	Corn	Soybeans
1975	$2.47	$4.80
1976	2.16	6.55
1977	2.01	5.68
1978	2.27	6.64
1979	2.40	5.95
1980	3.34	7.56
1981	2.51	5.83
1982	2.64	5.60
1983	3.30	7.81
1984	2.74	5.78

Table D.4 Corn Yields - Cornbelt Experiment Field (bushels per acre)

	Conventional		Ridge-Till		No-Till	
	c/s	c/c	c/s	c/c	c/s	c/c
1975	59.8	44.8	59.8	52.0	55.6	54.8
1976	60.5	55.1	65.8	54.1	65.8	60.7
1977	111.1	105.6	103.0	100.9	110.5	86.0
1978	92.3	86.3	85.6	77.7	89.9	86.9
1979	148.3	137.6	147.1	137.2	155.7	130.0
1980*	15.3	16.8	15.7	15.1	17.5	19.2
1981	128.8	120.3	128.8	120.3	137.7	118.8
1982	122.5	98.6	123.0	86.3	124.4	96.2
1983*	32.9	22.8	32.0	22.7	37.3	24.1
1984	63.8	46.2	67.2	49.0	59.8	41.8
Mean:	83.5	73.4	82.8	71.5	85.4	71.9
St.Dev:	43.8	41.9	42.7	40.2	45.6	38.0
Co.Var:	0.525	0.571	0.516	0.563	0.534	0.528

* Drought years - Crops were harvested as forage and yields recorded in lbs. of forage per acre. The following procedure was used to convert to bushels of grain per acre: Lbs. of forage per acre x $ value of forage per lb. divided by the per bushel corn price = per acre equivalent yield.

Table D.5 Soybean Yields - Cornbelt Experiment Field (bushels per acre)

	Conventional		Ridge-Till		No-Till	
	c/s	s/s	c/s	s/s	c/s	s/s
1975	33.4	29.7	32.6	30.7	34.2	30.6
1976	24.3	21.4	25.9	20.2	25.7	21.9
1977	42.6	42.0	39.6	40.6	42.4	42.6
1978	21.0	21.0	21.0	22.6	21.0	22.0
1979	37.2	36.0	34.0	34.8	38.8	36.3
1980	28.9	27.0	26.9	28.0	26.1	24.6
1981	40.9	41.9	41.1	39.6	44.0	41.4
1982	40.6	39.4	39.9	37.3	42.4	40.3
1983	13.9	11.2	13.5	12.1	15.9	11.9
1984	21.2	18.7	19.3	19.6	19.7	19.9
Mean:	30.40	28.83	29.38	28.55	31.02	29.15
St.Dev:	10.0	10.8	9.6	9.7	10.6	10.6
Co.Var:	0.330	0.373	0.326	0.339	0.341	0.365

Appendix E

This appendix contains estimated life and repair factors for farm machinery as given by Rotz (1985). These values are used to calculate the repair costs in Chapter 4.

Table E.1 Estimated Life and Repair Factors for Machinery (Rotz)

Machine	Life	Estimated Repair Factors	
		RC1	RC2
Tractors:			
2 wheel drive	10000	.010	2.0
Tillage:			
disc harrow	2000	.18	1.7
field cultivator	2000	.30	1.4
row crop cultivator	2000	.22	2.2
Planting:			
row crop planter	1200	.54	2.1
Harvesting:			
combine	2000	.12	2.1
Miscellaneous:			
shredder	2000	.23	1.4

Appendix F

Table F.1 gives the remaining value percentages of machinery by Mohaski (1982) used in Chapter 4 to calculate the salvage values. Table F.2 gives the index values used in calculating the depreciable values of farm machinery in Chapter 4.

Table F.1 Remaining Value of Machinery in Percent (Mohaski, et al.)

Life (Yrs.)	Tractor	Combine	Other
8	34.9	24.1	22.6
9	32.1	21.3	20.0
10	29.5	18.9	17.7
11	27.2	16.7	15.7
12	25.0	14.8	13.9
13	23.0	13.1	12.3
14	21.2	11.6	10.8
15	19.5	10.2	9.6

Table F.2 Index Values for Farm Machinery (Ag. Outlook)

Year	Tractor	Other
1979	122	119
1980	136	132
1981	152	146
1982	165	160
1983	174	171
1984	181	180
1985	178	183
1986	175	184
1987 (est.)	173	181

Appendix G

This appendix contains the worksheets used to calculate the enterprise budgets. Table G.1A calculates the herbicide costs per acre for the conventional tillage systems. Table G.1B calculates the same costs for the no-till systems, and table G.1C for the ridge-till systems. The insecticide and fertilizer costs are the same for each of the tillage systems: Table G.2 calculates the insecticide costs, and Table G.3 calculates the fertilizer costs. Tables G.4A, G.4B, and G.4C calculate the depreciable value for each piece of machinery for the conventional tillage, no-till, and ridge-till systems respectively. Tables G.5A, G.5B, and G.5C do the same for depreciation, interest, and insurance for each machinery item associated with the three systems. Table G.6 provides an enterprise budget summary.

Table G.1A Herbicide Costs for Conventional Tillage Systems

Input	$ Per Unit	Unit	Lb Active	Occur	Corn Quan	Bean Quan	Corn Cost	Bean Cost
Alachlor	23.00	Gal	4.0	100.0%	2.0	3.0	11.50	17.25
Atrazine	9.45	Gal	4.0	100.0%	1.5		3.54	0.00
Metribuzin	110.00	Gal	4.0	100.0%		.375	0.00	10.31
Total							15.04	27.56

Table G.1B Herbicide Costs for No-Till Systems

Input	$ Per Unit	Unit	Lb Active	Occur	Corn Quan	Bean Quan	Corn Cost	Bean Cost
Alachlor	23.00	Gal	4.0	100.0%	2.0	3.0	11.50	17.25
Atrazine	9.45	Gal	4.0	100.0%	1.5		3.54	0.00
Glyphosate	87.60	Gal	4.0	0.667%		1.0	0.00	14.61
				0.333%	1.0		7.29	0.00
Metribuzin	110.00	Gal	4.0	100.0%		.375	0.00	10.31
Paraquat	55.00	Gal	2.0	0.167%	.25	.183	1.15	5.03
2,4-D	11.40	Gal	4.0	0.167%	0.5		0.24	0.00
Total							23.72	47.20

Table G.1C Herbicide Costs for Ridge-Till Systems

Input	$ Per Unit	Unit	Lb Active	Occur	Corn Quan	Bean Quan	Corn Cost	Bean Cost
Alachlor	23.00	Gal	4.0	100.0%	2.0	3.0	11.50	17.25
Atrazine	9.45	Gal	4.0	100.0%	1.5		3.54	0.00
Glyphosate	87.60	Gal	4.0	0.667%		1.0	0.00	14.61
				0.333%	1.0		7.29	0.00
Metribuzin	110.00	Gal	4.0	100.0%		.375	0.00	10.31
Paraquat	55.00	Gal	2.0	0.167%		.174	0.00	4.79
Total							22.33	46.96

Table G.2 Insecticide Costs for All Tillage Systems

Input	$ Per Unit	Unit	Lb Active	Occur	Corn Quan	Bean Quan	Corn Cost	Bean Cost
Chlorpyrifos	1.56	Lb	1.3	100.0%	8.75		13.65	0.00
							-----	-----
Total							13.65	0.00

Table G.3 Fertilizer Costs and Rates for All Tillage Systems

Input	$ Per Unit	Unit	% N	% P_2O_5	Corn[1] Quan	Bean[1] Quan	Corn Cost	Bean Cost
NH_3	230.67	Ton	82.2%	0.0%	0.0707	0.0000	16.59	0.00
10-34-0	235.67	Ton	10.0%	34.0%	0.0588	0.0588	13.86	13.86
							-----	-----
Total Fertilizer Cost							30.45	13.86

[1]Fertilizer Rates per Acre (lbs. actual):

	N	P_2O_5
Corn	130	40
Soybeans	0	40

Fertilizer Cost per Pound Actual:

N	P_2O_5
$0.14	$0.347

Table G.4A Equipment List Price, Depreciable Base, and Purchase Year for Conventional-Till Continuous Corn

Implement	List Price	Life (Yr)	Life (Hr)	Year Purc	Begin Idx	End Idx	Remain Value	Deprec Value
2WD Tractor	$52,576	10	10000	1981	152	178	29.5%	$38,162
2WD Tractor	64,137	10	10000	1981	152	178	29.5%	46,554
Shredder	4,464	14	2000	1979	119	183	10.8%	2,467
Disc, 18 Ft.	10,736	14	2000	1979	119	183	10.8%	5,934
Field Cult.	9,513	14	2000	1979	119	183	10.8%	5,258
Planter	14,904	12	1200	1980	132	183	13.9%	9,138
Planter	14,904	12	1200	1980	132	183	13.9%	9,138
Cultivator	3,924	14	2000	1979	119	183	10.8%	2,169
Cultivator	3,924	14	2000	1979	119	183	10.8%	2,169
Combine	112,866	10	2000	1981	152	178	18.9%	81,923

Table G.4B Equipment List Price, Depreciable Base, and Purchase Year for No-Till Continuous Corn

Implement	List Price	Life (Yr)	Life (Hr)	Year Purc	Begin Idx	End Idx	Remain Value	Deprec Value
2WD Tractor	$22,215	10	10000	1981	152	178	29.5%	$16,125
2WD Tractor	52,576	10	10000	1981	152	178	29.5%	38,162
Shredder	4,464	14	2000	1979	119	183	10.8%	2,467
Planter	14,904	12	1200	1980	132	183	13.9%	9,138
Planter attch.	1,783	12	1200	1980	132	183	13.9%	1,093
Cultivator	3,924	14	2000	1979	119	183	10.8%	2,169
Cultivator	3,924	14	2000	1979	119	183	10.8%	2,169
Combine	112,866	10	2000	1981	152	178	18.9%	81,923

Table G.4C Equipment List Price, Depreciable Base, and Purchase Year for Ridge-Till Continuous Corn

Implement	List Price	Life (Yr)	Life (Hr)	Year Purc	Begin Idx	End Idx	Remain Value	Deprec Value
2WD Tractor	$22,215	10	10000	1981	152	178	29.5%	$16,125
2WD Tractor	66,659	10	10000	1981	152	178	29.5%	48,384
Shredder	4,464	14	2000	1979	119	183	10.8%	2,467
Planter	14,904	12	1200	1980	132	183	13.9%	9,138
Planter attch.	5,432	12	1200	1980	132	183	13.9%	3,330
Cultivator	8,167	14	2000	1979	119	183	10.8%	4,514
Cultivator	8,167	14	2000	1979	119	183	10.8%	4,514
Combine	112,866	10	2000	1981	152	178	18.9%	81,923

Table G.5A Equipment Annual Depreciation, Insurance, and Interest for Conventional-Till Continuous Corn

Implement	Deprec Value	Salvage Value	Annual Deprec	Annual Insur	Annual Interest
2WD Tractor	$38,162	$11,258	$2,690	$382	$2,671
2WD Tractor	46,544	13,733	3,282	466	3,259
Shredder	2,467	266	157	25	173
Disc, 18 Ft.	5,934	641	378	59	415
Field Cult.	5,258	568	335	53	368
Planter	9,138	1,270	656	91	640
Planter	9,138	1,270	656	91	640
Cultivator	2,169	234	138	22	152
Cultivator	2,169	234	138	22	152
Combine	81,923	15,483	6,644	819	5,735
			$15,074	$2,030	$14,205

Table G.5B Equipment Annual Depreciation, Insurance, and Interest for No-Till Continuous Corn

Implement	Deprec Value	Salvage Value	Annual Deprec	Annual Insur	Annual Interest
2WD Tractor	$16,125	$ 4,757	$1,137	$161	$1,129
2WD Tractor	38,162	11,258	2,690	382	2,671
Shredder	2,467	266	157	25	173
Planter	9,138	1,270	656	91	640
Planter attch.	1,093	152	78	11	77
Cultivator	2,169	234	138	22	152
Cultivator	2,169	234	138	22	152
Combine	81,923	15,483	6,644	819	5,735
			$11,638	$1,533	$10,729

Table G.5C Equipment Annual Depreciation, Insurance, and Interest for Ridge-Till Continuous Corn

Implement	Deprec Value	Salvage Value	Annual Deprec	Annual Insur	Annual Interest
2WD Tractor	$16,125	$ 4,757	$1,137	$161	$1,129
2WD Tractor	48,384	14,273	3,411	484	3,387
Shredder	2,467	266	157	25	173
Planter	9,138	1,270	656	91	640
Planter attch.	3,330	463	239	33	233
Cultivator	4,514	488	288	45	316
Cultivator	4,514	488	288	45	316
Combine	81,923	15,483	6,644	819	5,735
			$12,820	$1,703	$11,929

Table G.6 Conventional Corn - Soybean Enterprise Budget[1]

COST AND RETURNS	CORN	BEANS	TOTAL
VARIABLE COSTS PER ACRE			
1. Labor	3.75	4.66	8.41
2. Seed	13.05	10.20	23.25
3. Herbicide*	15.04	27.56	42.60
4. Insecticide*	0.00	0.00	0.00
5. Fertilizer*	30.45	13.86	44.31
6. Fuel ($/Gallon)=$0.96	3.26	4.04	7.30
7. Oil	0.49	0.61	1.10
8. Equipment repair	12.98	13.97	26.95
9. Custom Hire (Fertilizer Appl.)	2.82	2.82	5.64
10. Interest (1/2 VC @ 14%)			
- Owned Land	5.73	5.44	11.17
- Rented Land	4.46	4.28	8.74
TOTAL VARIABLE COSTS (Owned Land)	87.57	83.16	170.72
TOTAL VARIABLE COSTS (Rented Land)	68.10	65.43	133.53
FIXED COST PER ACRE			
11. Real Estate Taxes ($.50/$100 Land Value)			6.27
12. Interest on Land ($627*.06)			75.24
13. Share Rent CORN (Gross Return * 40%)	86.20		86.20
Share Rent SOYBEANS		75.64	75.64
14. Depreciation on Machinery			47.82
15. Interest on Machinery			44.94
16. Insurance and Housing			6.42
TOTAL FIXED COSTS (Owned Land)			180.69
TOTAL FIXED COSTS (Rented Land)			261.02
TOTAL COSTS PER ACRE (Owned Land)			351.41
TOTAL COSTS PER ACRE (Rented Land)			394.54
YIELD PER ACRE (Bu)	83.53	30.40	
PRICE PER BUSHEL	2.58	6.22	
GROSS RETURN PER ACRE	215.51	189.09	404.60
RETURNS OVER VARIABLE COSTS (Avg.)			259.91
RETURNS OVER TOTAL COSTS (Owned Land)			53.18
RETURNS OVER TOTAL COSTS (Rented Land)			10.05
ANNUAL NET RETURNS PER ACRE (Avg.)			22.99
NET RETURN TO MANAGEMENT (Total Farm)			7356.82

[1] 320 acres corn and 320 acres soybeans.

* Assumes landlord paying 2/5 of herbicide (8.52), 2/5 of insecticide (0.00), and 2/5 of fertilizer (8.86) per acre.

Appendix H

Analysis of Variance (ANOVA) was performed on the Powhattan corn yield data to determine if there were statistically significant differences between the 1974-79 and 1980-84 tillage systems. Table H.1 contains a statistical analysis of the corn yields as reported in the Cornbelt Experiment Field data.

Table H.1 Analysis of Variance Procedure (ANOVA) Performed on Cornbelt Experiment Field - Corn Yield Data.

DEPENDENT VARIABLE: YIELD

SOURCE[1]	DF	ANOVA SS	F VALUE	PR > F
Tillage method	2	20.16533333	0.49	0.6211
Rotation	1	3203.24266667	155.89	0.0001
Procedure	1	725.23266667	35.30	0.0001
Year	4	6063.89733333	73.78	0.0001

[1] Tillage method - Conventional, No-till, Ridge-till
Rotation - Continuous corn, Corn - soybean
Procedure - 1974-79 tillage methods, 1980-84 tillage methods
Year - 1974-84

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RISK ANALYSIS OF REDUCED TILLAGE CORN AND SOYBEAN ROTATIONS IN NORTHEASTERN KANSAS USING STOCHASTIC DOMINANCE TECHNIQUES

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CORN AND SOYBEAN ROTATIONS IN NORTHEASTERN KANSAS

USING STOCHASTIC DOMINANCE TECHNIQUES

ABSTRACT

Three tillage systems: conventional tillage, no-till, and ridge-till were evaluated using stochastic dominance with respect to a function analysis. Each tillage system is evaluated for three cropping patterns: continuous corn, corn after soybean rotation, and continuous soybean. Experiment Station yield and price data from 1975 to 1984 were used with 1985 cost of production estimates to determine expected returns to a 640 acre case farm for each system.

A reduced tillage system generated the highest return of all systems compared. Stochastic dominance analysis revealed that risk averse individuals would prefer a conventional tillage system over the conservation tillage systems. Those not averse to risk would show a preference for the reduced tillage corn - soybean rotation system. Small changes in production costs and yield differences could lead to indifference between a reduced tillage system and a conventional tillage system.