ECONOMIC ANALYSIS OF CONVENTIONAL AND NO TILLAGE WHEAT AND GRAIN SORGHUM ROTATIONS IN WEST-CENTRAL, KANSAS WITH RESPECT TO RISK: A STOCHASTIC DOMINANCE APPROACH

By

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CHAPTER ONE

INTRODUCTION

Overview

Dryland wheat and grain sorghum production on the Great Plains is a variable and often risky enterprise. Soil moisture is often a limiting factor in production. This, in addition to economic factors, has led to interest in strategies which will conserve and store moisture for use by the crop and thus increase yields and returns to the farmer.

Conservation tillage techniques have been of interest to producers desiring to achieve this as well as to reduce soil erosion. Conservation tillage is a broad term encompassing a variety of tillage practices and is somewhat difficult to define. Mannering and Fenster (1983), define conservation tillage as any tillage system that reduces loss of soil or water relative to conventional tillage. The emphasis is on the reduction of soil and water loss. It usually involves operations where plant residue remains on the surface, providing protection for the soil from wind and rain and allowing increased water intake and storage by the soil.

No-tillage systems are one type of conservation tillage. Phillips (1984), stated that no-tillage may be defined as the introduction of seed into untilled soil in narrow slots, trenches, or bands of sufficient width and depth for seed coverage and soil contact. Sprague (1986), notes that herbicides or other methods are used for weed control, and that the soil is undisturbed prior to planting in no-tillage systems.

In addition to reducing soil erosion and improving water retention and storage by the soil, no-tillage systems can offer the additional advantages of reduced fuel and labor costs, lower equipment requirements, greater flexibility in planting and harvest, and increased land use in some instances. These advantages may be offset however, by problems with weed control and associated costs; by problems with residue management and associated disease and insect control; or by cooler soil temperatures caused by the residue left on the surface. Though appearing to be less complex than conventional systems, no-tillage requires high levels of management and technology, which may be a disadvantage. These issues will be discussed further in the next chapter.

This study involves an economic analysis of wheat and grain sorghum rotations on conventional and no-tillage systems. Data are from an agronomic study conducted by Carlyle Thompson at the Fort Hays Branch Experiment Station near Hays, Kansas. Five different cropping systems are examined for each tillage system for a total of ten different crop-tillage systems. These systems are listed in Table 1.1.

Table 1.1

1.	Conventional Tillage Wheat-Fallow	CVWF
2.	No-Tillage Wheat-Fallow	NTWF
3.	Conventional Tillage Continuous Wheat	CVWW
4.	No-Tillage Continuous Wheat	NTWW
5.	Conventional Tillage Continuous Grain Sorghum	CVSS
6.	No-Tillage Continuous Grain Sorghum	NTSS
7.	Conventional Tillage Grain Sorghum-Fallow	CVSF
8.	No-Tillage Grain Sorghum-Fallow	NTSF
9.	Conventional Tillage Wheat-Grain Sorghum-Fallow	CVWSF
10.	No-Tillage Wheat-Grain Sorghum-Fallow	NTWSF

As described above, the no-tillage systems do not employ tillage in seedbed preparation or weed control. The crop is planted directly into residue left from the preceding crop. Herbicides are used in controlling weeds, both during the growing season and between crop years.

Conventional tillage is the set of tillage operations performed in preparing a seedbed for a given crop in a given geographical area (Mannering and Fenster (1983)). Tillage is also used as a means of weed control. Conventional tillage practices in this area involve the use of V-blades and disks in primary tillage to mix the topsoil. Secondary tillage may include rodweeders and mulch-treaders. In grain sorghum systems, cultivation is used during the growing season to supplement chemical weed control.

In this area, the traditional dryland cropping system has been a wheat-fallow rotation, where wheat is planted in September of one year, harvested in July of the following year, then left in a fallow or idle period for the next fifteen months until wheat is again planted. Weeds on the fallow ground are controlled by cultivation or chemicals depending on the tillage system. This system has the advantage over previous systems of providing the capability for moisture to be stored in the soil profile during the fallow period which can then be used by the crop. Two years are required to produce one crop on a given piece of land.

Continuous wheat systems produce a crop each year. Wheat is planted in September, harvested the following July, and planted again in September.

Continuous grain sorghum, like continuous wheat, produces a crop each year. Grain sorghum is planted in late May or early June, harvested in October, and is planted to grain sorghum the next May.

The sorghum-fallow system is similar to the wheat-fallow system. Grain sorghum is planted June, harvested in October, and the ground is idled for twenty months before sorghum is planted again. One crop is harvested every two years.

The wheat-sorghum-fallow rotation is the final system to be studied. This rotation allows two crops to be harvested every three years. Wheat is planted in September of the first year, harvested in July of the next year, then the field is left fallow until June of the third year when grain sorghum is planted. The grain sorghum is harvested in October of the third year and the field remains idle for eleven months until wheat is once again planted.

Each of these systems will be analyzed for effects of risk by examining the variability of net returns and average annual net returns. Stochastic dominance techniques will also be used. First degree stochastic dominance (FSD), second degree stochastic dominance (SSD), and stochastic dominance with respect to a function (SDWRF), are used in determining producer preferred systems. FSD identifies strategies preferred by individuals who prefer more income to less. SSD criteria identify strategies preferred by individuals who receive greater satisfaction from increases in income at low income levels than increases at high levels of income. These individuals are risk averse. SDWRF is a more flexible approach which orders choices for decision-makers using any specified risk aversion interval.

Statement of the Problem

Historically, weed control has been one of the primary reasons for tillage. Other reasons given for tillage include aeration of the soil when it has been compacted by heavy equipment, control of insects and disease through burial of plant residue, leveling or shaping of the field following previous tillage or harvest during wet conditions, incorporation of fertilizers and other chemicals, and the aesthetically pleasing appearance of a clean-tilled field. Tillage can also raise the soil temperature in regions with shorter growing seasons, allowing earlier planting of the crop.

Not all of these reasons are necessarily valid or advantageous however. Tillage can encourage soil erosion by leaving the soil surface unprotected to wind and rain. In addition, Sprague (1986), notes that under tillage, soil deterioration can occur, moisture management can be inadequate, and that most weedy species have actually not been adequately controlled by tillage.

With this in mind, conservation tillage offers potential in reducing soil erosion as well as dealing with some of these problem. By the definition above, conservation tillage involves systems which reduce soil and water loss. This is usually done through reduced tillage methods, including no-tillage, and maintains crop residues on the soil surface which protect the soil. Benefits may include reduced soil erosion, soil moisture conservation, reduced fuel and labor costs, and timeliness of field operations such as planting.

However, concerns do exist regarding weed control, yields, and crop rotation on conservation tillage systems. Weed control is usually accomplished through increased use of herbicides, which translates into higher costs, offsetting some of the gains from lower fuel, labor, and machinery costs. Yields have been shown to be higher, lower, and unchanged on conservation-tillage systems, reflecting the presence of many variables including soil, climate, and management. Traditional crop rotations may be impacted by changes in tillage practices and require adjustment. Thus, economic analysis is needed to evaluate the tradeoffs that exist between conventional and conservation tillage.

Objective of the Study

The primary objective of this study is to analyze the economic potentials of and the risks associated with conventional tillage and no-tillage wheat and grain sorghum rotations in West-Central, Kansas. Analysis will provide information regarding which system will provide the highest annual net returns in West-Central, Kansas, the risk associated with each system, and the effect of tillage practices on annual net returns and associated risk.

Specific study objectives are:

1) Identify conservation tillage cropping systems which are technically feasible for West-Central, Kansas based on recommendations of agricultural experiment station personnel,which can be compared with conventional tillage cropping systems.

2) Following recommendations from agronomists and agricultural experiment station personnel, establish typical cropping practices that would be followed in each system.

3) Collect yield data from agricultural experiment station research studies for each cropping system.

4) Collect regional price data from state agricultural statistics office.

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

6) Establish a machinery complement capable of meeting tillage and planting requirements within an optimal time period.

7) Estimate the variable and fixed costs of each cropping system, based on characteristics of a typical West-Central, Kansas farm.

8) Examine potential risk by variance of yields, prices, and net returns for each system over the past eleven years, using an enterprize budget framework.

9) Use stochastic dominance techniques (FSD, SSD, SDWRF) to provide a ranking of the cropping systems with consideration for risk.

<u>Study Area</u>

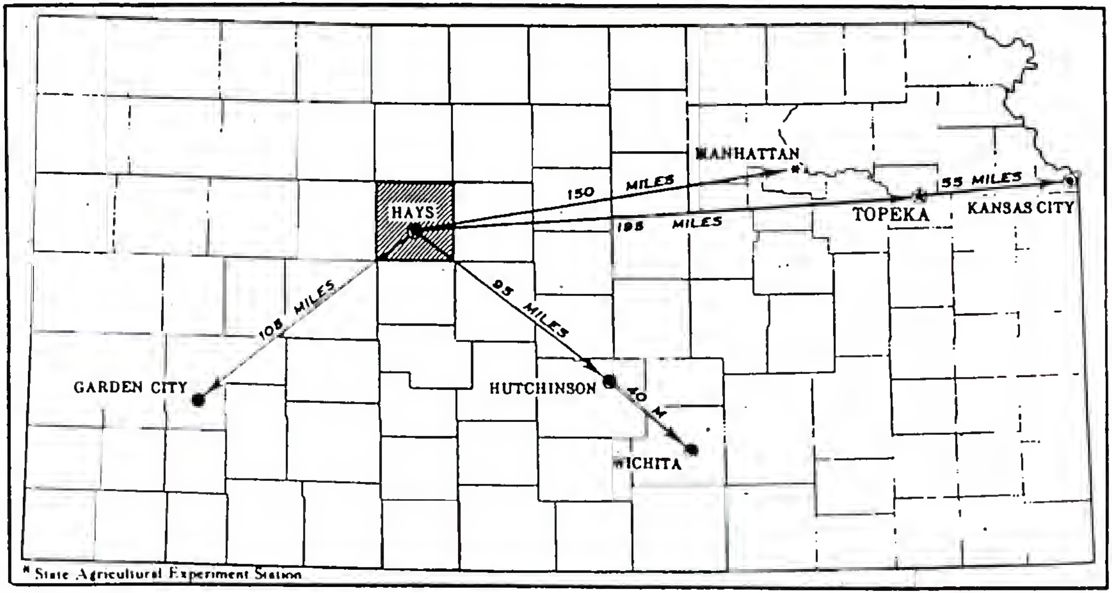
Yield data used in this study were collected at the Fort Hays Branch Experiment Station, located one mile south of Hays, Kansas. Hays is located in Ellis County in the West-Central part of the state (Figure 1.1). Situated at an elevation of about 2000 feet, the general topography is a flat, gently rolling plain, sloping from west to east. The climate is semi-arid.

Agriculture is the primary industry of Ellis County, with diversified operations producing wheat, grain sorghum, and livestock, primarily beef, as the main products. Small amounts of alfalfa, corn, oats, and native hay are also produced. Most of the crops are produced under dryland conditions. The largest non-agricultural industry in the county is the oil industry.

<u>Soils of the Study Area</u>

The soils of Ellis County are classified into seven general soil associations, with Harney-Carlson-Armo and Mento-Brownell-Wakeen associations covering over one-half of the county. Harney silt loam is the soil series at the experiment station on which the yield study has been conducted.

FIGURE 1.1: Location of Ellis County, Kansas



Source: Glover, et al. (1970)

These soils belong to the soil order, Mollisols and soil groups Argiustolls and Haplustolls. Mollisols generally developed under grass vegetation in temperate climates and are common on the plains of the north central United States. The soil group, Argiustolls, occupies slopes that are mostly moderate or nearly level sloping on upland. Argiustolls are deep, well-drained soils that have available moisture during the growing season. Haplustolls are well-drained, moderately deep to deep soils occurring on uplands. The natural vegetation is predominantly grasses and forbs. Slopes vary from nearly level to steeply sloped. Both of these soil groups are quite suited for wheat and grain sorghum production on suitable slopes.

The Harney soil series, belonging to the group, Argiustolls, consists of deep, well-drained soils formed in the silty loess found in much of the Great Plains. The dark silt loam surface layer is about 10 inches thick and the 30 inch thick subsoil is silty clay loam in a representative soil profile. Underlying material is a calcareous, silty clay loam.

Harney soils have a high available water holding capacity. Permeability is moderately slow. Water erosion is a hazard on the sloping soils and wind erosion is a hazard on fields left bare of vegetation. Most of the areas with suitable slopes are cultivated. Sloping areas not cultivated are in native grass and used for range.

<u>Climate of the Study Area</u>

The climate of Ellis County is semi-arid, continental. Located on the edge of the Great Plains, this area represents somewhat of a transition zone between the less arid regions to the east and the more arid High Plains.

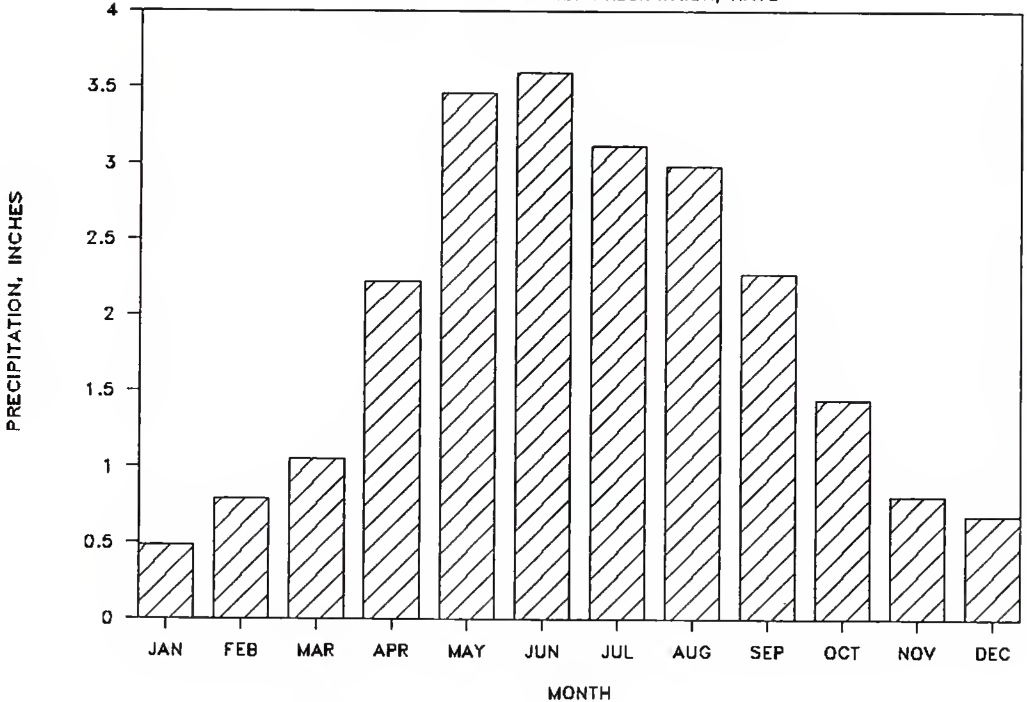
The climate is characterized by abundant sunshine, low humidity, moderate winds, cold winters, warm to hot summers, light winter precipitation with most of the rainfall occurring in late spring and summer.

Average annual rainfall is 22.9 inches, but precipitation varies by month and by year. Figure 1.2 shows average monthly precipitation, while Figure 1.3 illustrates annual precipitation since 1900. More than three-fourths of the average annual precipitation falls during the growing season. Dry periods are not uncommon and extended periods of drought can occur. As in most continental climates, violent thunderstorms can occur, bringing heavy rain, strong winds, and hail. The heavy rains may cause run-off leading to soil erosion on sloping and unprotected land.

Temperatures vary as well. Average monthly temperature is 29 degrees Fahrenheit in January and 79 degrees Fahrenheit in July. The normal date for the last frost in the spring is April 27 and for the first frost in the fall is October 15. The average freeze-free period is 171 days.

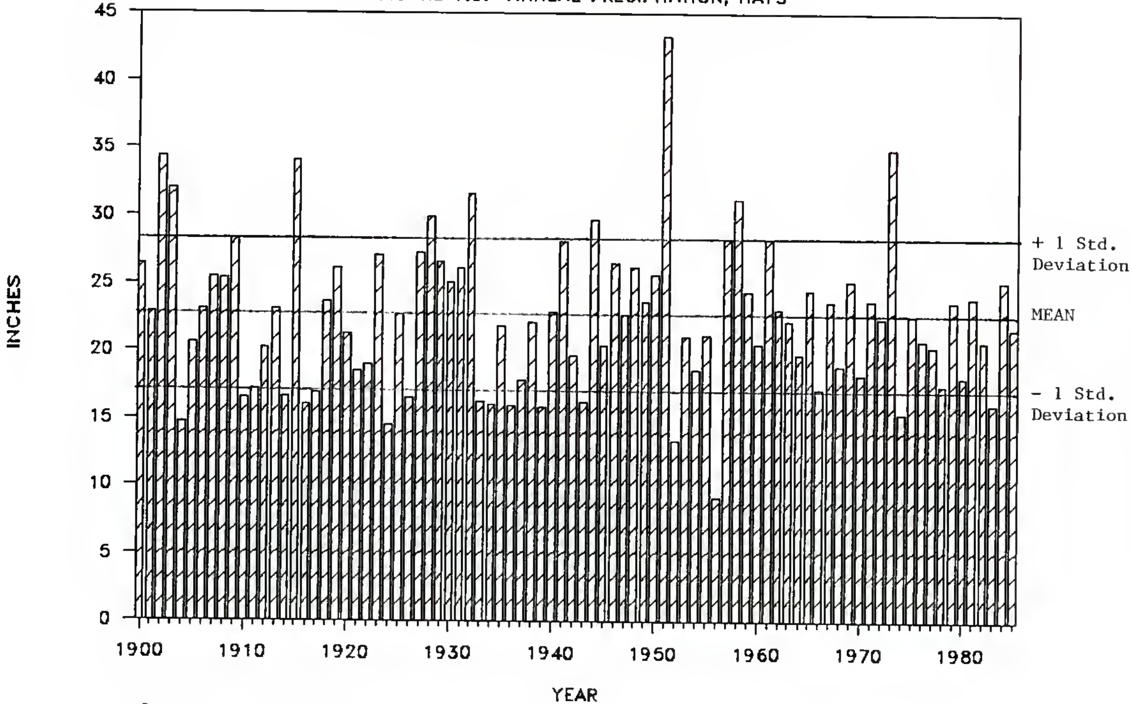
This area experiences moderately strong winds in all seasons. Winds are strongest in the spring with March, the windiest month, having an average hourly windspeed of about 15 miles per hour.

FIGURE 1.2: MONTHLY PRECIPITAION, HAYS



Source: Glover (1970)

FIGURE 1.3: ANNUAL PRECIPITATION, HAYS



Source: Bark (1987)

CHAPTER TWO

REVIEW OF LITERATURE

The Great Plains is a diverse area stretching from Mexico into Canada along the eastern slopes of the Rocky Mountains. The semiarid, continental climate which characterizes this area contributes to soil erosion by wind and water. Large sections of the area receive less than twenty inches of annual precipitation creating dry conditions conducive to wind erosion. However, heavy rains may fall in a short period of time, creating the potential for soil erosion by water.

In addition to concern about soil erosion, producers are interested in water conservation for crop production. Available water to support plant growth is recognized as the principal limiting factor for crop production in the Great Plains (Hanway, 1984). Because of these and other reasons, tillage practices have changed in recent years and interest in conservation tillage systems has increased.

History of Conservation Tillage

The philosophic origins of tillage in this country can be traced to Europe. Jethro Tull, an English landowner in the first half of the eighteenth century, promoted the idea that more and deeper tillage is better and gave his life to developing and improving plows and tillage implements. In this country, the development of an effective steel moldboard plow by John Deere in 1838 allowed this philosophy to continue and helped pave the way for agricultural expansion into the middle areas of the United States.

The moldboard plow, which buries nearly all crop residue, exposes the soil surface to wind and water, potentially leading to erosion.

Widespread use of this implement caused damage to the soil through erosion and deterioration of soil structure, and decreased productivity resulted from lower organic matter and fertility levels and increasing salinity in some cases (Sprague, 1986).

Concern over these matters began to surface in the early twentieth century and the concept of less tillage began to emerge. Early attempts at erosion control were generally limited to cases of extreme soil erosion and usually involved the complete elimination of plowing, and were often accompanied by a decrease in yield and an increase in weed control problems (Cosper, 1983).

The decade of the 1930's dramatically illustrated the problems associated with excessive tillage and brought permanent changes to the area of the Great Plains. Extreme and drought and associated high winds contributed to the "dust bowl" conditions caused by wind erosion of the soil. This, in addition to the economic depression occurring then, forced the outmigration of farmers from this area, and forced those who stayed to change tillage practices.

Another result of this period was the establishment of the Soil Conservation Service as an agency in the United States Department of Agriculture. Much of this was due to the efforts of Hugh Bennett. Bennett had been active in making known the urgency of conservation from the early 1920's and with the establishment of the SCS in 1933 began to work to bring about the use of soil conservation practices on the nation's farmland.

In the Great Plains, recognition of the inherent dangers of a bare soil in enhancing erosion as well as the need for better water conservation for crop growth prompted research into fallow and mulch tillage techniques. Duley and Russel at Lincoln, Nebraska were pioneers in this area, as they developed extensive experimentation on stubble-mulch farming (Fenster, 1984). In this type of operation, subsurface tillage was used to cut weed roots below the surface, leaving plant residues on the soil surface to protect it from erosion, to increase water infiltration, and to reduce runoff and evaporation. This contrasted with the use of the moldboard plow, which buried all crop residue.

The advent of selective chemical herbicides provided a way to control weeds in crops without dependence on tillage. The release of 2,4-D in 1944 was the beginning of a new era in agriculture. Application of herbicides in small amounts to control specific types of weeds in a crop was now possible. This allowed the possibility of further reducing the amount of tillage needed and even eliminating tillage entirely. Studies examining no-tillage cropping systems have been initiated and no-tillage wheat and grain sorghum are the focus of this study.

Reasons for Tillage

One of the primary reasons given for tillage is weed control. Adequate weed control is essential to successful crop production. Tillage uproots weeds, severing their contact with the soil, leading to death by dessication or by being covered and is used both prior to planting to prepare a weed-free seedbed and after planting during the growing season to kill weeds which have emerged since planting. As tillage decreases, reliance on chemical weed control becomes greater.

Kells and Meggitt (1985) note that tillage has a significant impact on weeds, and not only in a negative sense. Tillage favors seed germination of most annual weed species because it disturbs the soil, stimulating the seed to germinate by being positioned in a more favorable environment that includes moisture, oxygen, proper temperature, and light which are factors affecting germination. As tillage is reduced, annual broadleaved weeds generally decrease and there is an increase in perennial weeds and annual grasses.

Other reasons for tillage listed by Phillips (1986) include alteration and enhancement of soil physical properties, seedbed preparation, incorporation of fertilizers and other chemicals, managing residue to control insects, disease, and other pests, and the leveling or shaping of a field following previous tillage or harvest during wet conditions.

Tillage can affect soil physical properties. Soil bulk density and porosity are properties that influence air and water movement in the soil and thus the potential productivity of a given soil. Bulk density, expressed in units of mass per volume and usually as grams per cubic centimeter, describes the density of the soil, that is, how closely the soil particles are to each other. Porosity is related to bulk density since the closer the particles are, the less space there is for air or water. Tillage stirs and loosens the soil, improving aeration and decreasing bulk density.

Blevins, Smith, and Thomas (1984) cite studies showing that tillage lowered bulk densities and increased porosity when compared to no-tillage systems. They also note however, that no-tillage treatments still had higher volumetric water contents and that differences in bulk densities and porosities did not occur below a depth of 30 centimeters. They also found that water infiltration rates were generally higher on no-tillage systems, probably due to the continuity of large pores not interrupted by tillage.

Tillage can also affect soil structure, the aggregation of soil particles. Soil structure is affected by organic matter, and long-term tillage causes a decline in organic matter content due to the increased oxidation of the organic matter caused by tillage (Hillel, 1971). In addition, excessive tillage or tillage under wet conditions can cause the soil aggregates to break down into smaller particles causing a "puddling" or crusting of the soil. Formation of tillage pans caused by wheel traffic of heavy equipment is another possible result of tillage.

Seedbed preparation is an important reason for tillage. Proper contact between the seed and the soil is the goal in preparing a seedbed. Moisture, oxygen, and proper temperature are required for germination to occur. In the past, tillage has often focused on a clean-till type of seedbed preparation, which is aesthetically pleasing, but may actually be less effective in providing the proper elements for germination. Tillage may allow the top layer to dry too much, causing a lack of moisture for the seed at a crucial time. Griffith, Mannering, and Box (1986) also note that tillage may cause the soil to crust, preventing or inhibiting emergence of the seedling.

The management of crop residue is another reason to till. Crop residue on the soil surface may have undesirable effects including reduced emergence, growth, and yield of the following crop (Triplett, 1986). This may be a result of several factors caused by the residue, among which are lower soil temperatures, especially at planting, the shading of the soil as the seedling emerges, slowing growth, and the presence of pests including disease and insects which may harbour on the residue during the winter. Tillage buries or destroys residue and eliminates these problems.

The final reason to till which was listed was to level or shape a field following previous tillage or harvest operations under wet conditions. Harvest under wet conditions is sometimes necessary, because the crop may deteriorate if left in the field until dry conditions exists. Machinery operations under wet conditions can damage the soil structure and necessitate further tillage to repair the damage caused and to allow future operations to take place.

<u>No-Tillage Agriculture</u>

No-tillage agriculture differs from conventional or reduced tillage agriculture in that no-tillage does not use tillage, but rather a spray and plant system. Conventional tillage itself has changed in recent years. Triplett (1985) notes that by this decade, conventional tillage no longer included exclusive use of the moldboard plow for primary cultivation and that the number of trips across the field in conventional tillage was about one-half of the average number in 1930.

In this study, conventional tillage refers to a surface tillage type of agriculture where the topsoil is stirred using V-blades and disks as primary tillage and disks and a rodweeder as secondary tillage as needed. No-tillage refers to the use of chemicals in controlling pests and does not use tillage at all. The seed is planted directly into the residue of the previous crop.

Use of conservation tillage and specifically no-tillage in the Great Plains has increased in recent years. Christensen (1984) found that acreage under no-tillage cropping systems in the Great Plains increased from 517,700 acres in 1973 to 2,841,400 acres in 1984, an increase of 449%.

Interest in no-tillage is due to concerns about soil and water conservation as well as potential savings in costs. No-tillage provides benefits such as protection against soil erosion and improved water retention and storage by the soil, reduced energy and labor costs, reduced equipment requirements, reduction in annual weed problems since many annual weeds need to be incorporated into the soil for germination, greater flexibility in planting and harvest, and in some instances, increased land use, as this practice is well suited to many soil types (Wicks, 1985).

Disadvantages of no-tillage include increased herbicide costs for weed control and difficulty in crop residue management resulting in planting and seed placement problems, lower soil temperatures at planting time causing slower seedling emergence, and problems controlling disease, insects, and other pests (Frye, 1984). Other disadvantages include difficult fertilizer application and placement and the fact that new planting equipment often must be purchased or old equipment must be modified (Wicks, 1985).

Soil erosion is a significant problem in the Great Plains region. Soil formation generally occurs at a rate of about 5 tons per acre per year and erosion which is less than that rate is not a great problem. However, Christensen (1984) estimates that approximately 14% of the cropland acreage in the Great Plains is eroding at a rate which is greater than this. Erosion in the Great Plains is generally caused by wind, though water erosion can occur.

Wind and water erosion can be controlled to some extent by the maintenance of surface residues. This is the advantage of no-tillage cropping systems. Crop residues are maintained on the soil surface continuously, protecting the soil. Mannering and Fenster (1983) note that residues allow greater water infiltration, reduce runoff velocity, and reduce wind velocity at the soil surface, reducing the soil loss due to wind erosion.

Soil water capabilities are also improved. Increased water infiltration due to more and larger undisturbed pores in the soil, increased water retention by the soil, and in some cases, increased water availability to plants, are potential benefits of no-tillage systems (Blevins, et al., 1984).

No-tillage systems offer some savings in costs over conventional tillage systems. Fuel and labor costs are lower due to fewer and less energy intensive field operations. Epplin et al. (1982) found labor costs for zero tillage systems to be only 20% of the total for the conventional tillage plow system. The reduced tillage systems also were found to require three to five gallons less fuel per acre than the conventional system.

In addition, machinery requirements are generally lower for no-tillage systems reducing fixed costs of depreciation, interest, insurance, and housing. Chemical application equipment, planting equipment, and tractors are the basicly the only implements needed (Throckmorton, 1985).

Increased flexibility in planting and harvest and increased land use are related. No-tillage systems have the advantage of not requiring tillage prior to planting and can be used in areas where soil moisture and slow drying conditions may prevent cropping practices to occur. It is possible to wait until the soil dries and still achieve the timeliness factor that is important in planting.

On the negative side, increased amounts of herbicides must be used to control weeds in lieu of tillage. Chemical control of weeds became possible with the introduction of selective herbicides such as 2,4-D. A much broader range of chemicals is available today, including preplant, preemergence, post emergence, preharvest, and post harvest herbicides as well as systemic herbicides capable of killing all vegetation (Worsham and Triplett, 1985). However, these chemicals add a cost to production that offsets at least to some extent the cost reductions outlined above.

Other methods of weed control have been examined, including increasing seeding rate and narrowing row spacing (Vander Vorst, et al., 1983), but some chemical weed control was still needed. Crop rotation can be effective as well (Worsham and Triplett, 1985). Forcella (1986) examined the timing of weed control in no-tillage wheat and found that the timing of weed control is important and differs from that of conventional tillage.

Proper management of crop residues left on the soil surface in no-till systems is essential. Excessive residues can make planting difficult, lower soil temperatures, create aeration problems in wet seasons and on heavy soils, and perhaps contribute to lower yields due to phytotoxins produced during residue decomposition. Increased disease and insects may occur because the residue provides a place to overwinter.

Studies have been undertaken to examine some of these problems. Sanford (1982) found increased yields in no-till systems when wheat stubble is burned following harvest. Langdale, et al. (1984) discovered that no-tillage systems had manageable residues over four years and produced higher wheat and grain sorghum yields than the conventional system examined. Cochran et al. (1982) examined four residue management systems in winter wheat: standing stubble, complete residue removal, moving the crop residue from the seed row, and residue incorporation. During the three year study, winter wheat yields from plots direct drilled into residue were equal to those tilled and seeded conventionally.

A study to examine surface residue effects on soil temperatures and sorghum germination was conducted by Unger (1978). Only the very high rates of wheat straw residue affected sorghum germination and growth. Moderate amounts, while delaying the time that the soil reached favorable temperatures for germination, did not affect germination and growth since temperatures were near optimum before normal planting dates.

Regarding the aspect of plant disease and surface residue, Sumner et al. (1981) concluded that "minimum tillage practices may increase, decrease, or have no effect on plant diseases". It was noted that leaving plant debris on the surface may allow pathogens to overwinter or survive until the next crop is planted, but conditions favorable for biological control of pathogens may also be increased. Tillage practices may indirectly influence plant diseases by causing changes in the cultural practices but general conclusions are impossible to draw. Data must be available for a specific region in order to assess the effects of tillage on the incidence of plant disease.

Fertilization, though not a major problem in no-till systems, is of concern. Most of the problems that exist are associated with nitrogen, a very important fertilizer. Cooler, wetter soils, as generally found in no-till versus conventional tillage systems, affect many of the processes that control the content and availability of nitrogen in the soil. Availability of N is generally less in non-tilled soils than in tilled soils for the first several years after converting to no-tillage (Fox and Bandel, 1985). Greater leaching due to higher soil moistures and immobilization due to higher organic matter content may be at least part of the cause. Also, since nitrogen generally is not incorporated in no-till soils, the possibility exists for ammonia (NH_3) to volatilize and be lost into the atmosphere. These problems may create the necessity for higher fertilizer rates.

Another disadvantage to be discussed is the need for new or modified planting equipment. This is not a severe problem, as many farmers are able to make modifications to existing equipment themselves and viable no-till equipment is becoming available from equipment retailers. There is a transition that must be made however, and it may slow adoption of conservation tillage practices somewhat.

One further topic which should be discussed when considering no-tillage is the increased use of chemicals generally associated with reduced tillage systems and the external effects of this elevated use. Direct benefits of pesticides are obvious as they control weeds, insects, and plant disease. However, additional problems may exist which are not as obvious.

Kearney and Helling (1982) divide these problems into two categories, environmental processes and specific compound/byproduct problems. Much of the concern has focused on the former category and they further break down the problems associated with environmental processes into movement, including drift, leaching, and runoff; persistence and plant uptake; adaptation by pests resulting in resistance to chemicals; and exposure to the user and the consumer.

The chemicals used in agriculture include insecticides, herbicides, and fungicides. Peskin (1986) indicates that cropland accounts for about one-third of the total pollutants found in the waters of the United States. Runoff and leaching of chemicals are the primary souces of this non-point pollution. These chemicals may have deleterious effects on aquatic life, on wildlife, and on human life if the water is a source for human consumption.

McWilliams (1984) examines groundwater pollution in Wisconsin, finding that greater use of agricultural chemicals and irrigation has led to contamination of the state's groundwater by chemicals such as aldicarb, an insecticide/nematicide, and by nitrates. White, et al.

(1981) studied nonpoint source pollution in Georgia and found a direct relationship between higher levels of pollution and increased crop acreages.

In addition to offsite problems, Hinkle (1983) deals with the factor of herbicide carryover or persistence, noting that damage to a sensitive crop can occur, reducing yields. Also, resistance to a pesticide can develop in a pest, causing problems in controlling the pest. Higher application rates may be used, but this may not take care of the problem. Dahlsten (1983) notes that in addition to instances of resistance by pests, resurgence and secondary pest outbreaks can occur as well. This may occur by reducing the target's natural enemies as well as creating a void which may be filled by other pests.

Crosson (1986) argues that greater use of chemicals on reduced tillage acreages does not necessarily translate into higher environmental costs. He cites a U.S.D.A. study which found only small differences in pesticide use between tillage systems and that when considering the reduced erosion found with reduced tillage systems, actual off-farm chemicals were generally not much higher than for conventional tillage systems.

One other source which provides a fairly comprehensive examination of the effects of pesticides on the environment is Brown (1978). Effects of insecticides, herbicides, and fungicides on soil and water flora and fauna as well as effects on vertabrates are considered.

Effects of Conservation Tillage on Yield

The effects that conservation tillage has on crop yields are important and must be considered. Follett (1984) lists conditions that should result when using conservation tillage systems. Included in this list is that there should be equal or better crop yields. Yields directly influence gross returns and thus net returns to management. A decrease in yield results in lower gross returns and may result in lower net returns if there is not a corresponding decrease in costs.

Conservation tillage may affect yields in several ways. Higher soil moistures generally found in reduced tillage systems may lead to higher yields, especially in more arid climates as found in the Great Plains region. Yields may also be higher due to decreased soil erosion found in conservation systems. Yields may be negatively affected by lower soil temperatures, incidence of pests including weeds, insects, or disease, or excess crop residues which slow plant emergence and growth.

Tillage studies have been conducted to examine the effects of conservation tillage on wheat and grain sorghum yields. For wheat, there is no consistent conclusion that can be determined as to whether the use of conservation tillage affects yield.

Reed and Erickson (1984) found that wheat yields varied a great deal for different locations in the Great Plains. In North Dakota, conventional systems outyielded conservation systems. Moving south through South Dakota, Wyoming, and Nebraska, the systems were about equal with conservation tillage occasionally having a slight advantage. In Kansas and Colorado, conservation tillage had consistent yield advantages over conventional tillage. This was attributed to length of growing season, with conservation tillage systems having an advantage in areas with a longer growing season.

In contrast, Karlen and Gooden (1987) show no-till wheat yields to be significantly lower than yields with disk tillage. Poor seed-soil contact was presumed to cause erratic stands and lower yields. The study took place in the southeast coastal plains of the United States.

Raines (1977), in studying the effects of no-till and conventional tillage systems on wheat yield, found that continuous wheat yields in the conservation tillage studies to be variable and poor and that wheat yields actually responded favorably to tillage.

Other studies are less conclusive. Cox et al. (1986) concluded that there were no significant differences in tillage systems when conventional tillage, minimum tillage, and no-tillage were used. Izzaurralde et al. (1986) found that lack of adequate seed placement due to the presence of surface residues under conservation tillage reduced wheat yields, except in dry years when no-till yields were significantly higher, probably due to higher soil moisture. A study to compare no-till wheat performance with controlled wheel traffic found no difference between no-till and conventional till except in dry years when no-till had significantly lower yields (Gerik and Morrison, 1985).

Studies examining the effect of surface residue on yield were summarized above (Sanford, 1982; Langdale, 1984; Cochran, 1982). Wheat yields on no-till systems may be higher, lower, or the same as those on conventional tillage.

Grain sorghum yields demonstrate much of the same ambiguity as wheat yields. Reed and Erickson (1984) in the same study cited above, found that grain sorghum yields in Kansas and Nebraska were consistently greater on conservation systems than conventional tillage systems. Conservation tillage systems here included chemical conservation tillage, ecofallow, and no-tillage systems.

Baumhardt, Zartman, and Unger (1985) determined that dryland no-tillage grain sorghum yields were greater than disk tillage yields and attributed the difference to greater stored water at planting.

On the other hand, Gerik and Morrison (1984) conclude that grain sorghum yields did not differ significantly between no-tillage and conventional tillage. They found in their study that soil water contents were not significantly different between tillage treatments, though the trend was for there to be slightly higher amounts of water available in the no-till systems.

Studies at western Kansas experiment stations examining tillage systems and also cropping systems have found yields of wheat and grain sorghum to be generally equal or better on no-tillage than on conventional tillage (Gwin and Conrad, 1985; Norwood, 1985; and Thompson, 1985). In addition, the wheat-sorghum-fallow crop rotation has shown higher grain sorghum yields and equal wheat yields when compared with other cropping systems, though this has not been consistent (Nilson et al. 1985).

Economic Analysis of Conservation Tillage

Despite potential problems with conservation tillage and specifically no-tillage systems, adoption of these systems by farmers is taking place. Triplett (1985) notes aspects of reduced tillage which should be considered before adoption: 1) Profit is of prime importance to the farmer and a change to a new tillage system must be an improvement economically over that which is abandoned;

2) Elements of risk should not increase significantly; and 3) Systems must be matched to local soils, crops, pests, climate, equipment, and personnel. It is with the first two that this section is concerned.

For conservation tillage systems to be viable economically, any declines in yield which might occur must be offset by an equal or greater savings in the costs associated with such a system. Additional costs which are incurred, including increased herbicide costs, must be taken into account as well.

Economic analysis of conservation tillage has not been well documented for wheat or grain sorghum, especially in the Grain Plains area and particularly for no-tillage agriculture. This contrasts with the situation for corn and soybeans in the Corn Belt area, where interest in conservation tillage has spurred agronomic and economic research.

Epplin et al. (1983) examined tillage systems for wheat and found that the additional costs of the herbicides in the reduced tillage plots exceeded the value of fuel and labor savings. However, when fixed machinery costs were considered, some conservation systems were competitive, though not clearly superior.

Johnson and Ali (1982) examined income and risk aspects of wheat-fallow cropping systems in western North Dakota and found that though wheat-fallow systems reduced risk, net returns were substantially lower than more intensive cropping systems.

Harman (1984) used enterprise budget analysis to examine conventional and conservation tillage grain sorghum. His findings indicated that when total production costs were considered, significant cost reductions were realized and these, coupled with higher grain sorghum yields, allowed the conservation tillage systems to achieve higher returns to land and management.

Williams (1988) used enterprise budgets and stochastic dominance analysis of annual returns to examine conventional and conservation tillage systems for wheat and grain sorghum in Western Kansas. Stochastic dominance with respect to a function is used to analyze the systems for risk-neutral and risk averse individuals. It was determined that risk averse decision makers preferred the conservation tillage systems over the conventional wheat-fallow cropping system. Increased yields, attributed to higher soil moisture, combined with lower fuel, labor, and repair costs more than offset the higher chemical costs of the conservation systems.

CHAPTER THREE

CONCEPTUAL CONSIDERATIONS

Economic theory provides a framework for analyzing problems relating to production of output and to the allocation of scarce or limited resources. The problem of scarcity creates the necessity for some method of allocating resources in an orderly fashion. Prices meet this need, serving the dual function of rationing available quantities of goods and financing their production costs. Prices force producers and consumers to make choices, based on information available to them, as to the best alternative available in order to achieve a given goal.

Economics then, is a study of decision-making by producers and consumers. This study analyzes the production of wheat and grain sorghum in conventional tillage and no-tillage systems for West-Central, Kansas, utilizing enterprise budgets which analyze costs and returns. Because the presence of risk influences decisions by producers, each system is analyzed with consideration given to risk, using stochastic dominance techniques.

Economic Theory and Enterprise Budgets

The goal of profit maximization is assumed to underlie traditional economic theory of the firm. Profit maximization occurs when the cost of a marginal or additional unit of input, the marginal factor cost (MFC), is equal to the value of additional output produced by that input, the marginal value product (MVP).

In the short run, the producer has variable and fixed inputs. Variable inputs or costs are a function of the amount produced and do not occur unless a producer attempts to produce an output. The operator has control over these inputs and their level of use. Examples of these would include seed, fuel, or pesticides. Fixed inputs are those which do not change with the level of output. These remain the same regardless of whether production takes place or not and would include machinery, land, or other items which would be difficult to change in a short period of time. In the long run, it is assumed that all inputs are variable and that the operator is able to change the amounts of these inputs in the long run.

Selection of the appropriate amount of variable inputs depends largely on (1) the prices of the inputs and the output, and (2) the technical relationship between the inputs and the output. This technical relationship between the amount of input used and the corresponding output is referred to as the factor-product relationship or the production function. It describes the effect of additional use of the variable input on the amount produced.

An important facet of economic theory is the law of diminishing returns. This states that the marginal product, that is, the additional amount produced from the addition of an input, will eventually decline at some level of use. Another way to state it is that this occurs when an additional unit of the input adds less to total output than the previous unit. When this happens, marginal costs, the cost of producing an additional unit of output, will rise. Further production becomes less profitable and a point is reached where the marginal cost, the cost of producing an additional unit of output, equals the marginal revenue, the additional revenue gained from that unit of output. This is another way to describe the point of profit maximization, where the marginal revenue equals the marginal cost.

Within this economic framework, enterprise budgets are used to analyze crop-tillage systems. Enterprise budgets are based on the system of production that identifies the specific output to be produced, the sequence of operations, the approximate time the operations are to be performed, and the inputs required for the production process (Boehlje and Eidman, 1984).

In this study, the enterprise budget represents only one point on the production function. It is assumed that the experiment station agronomists have selected input levels which are at or near the optimal amount of use (MVP=MFC), and that this point is at or near the level of profit maximization for each system.

Conservation tillage systems, including no-tillage, can thus be compared with conventional systems using this format. Benefits of conservation tillage include reduced costs of production, including labor, fuel and oil, and reduced equipment costs of repairs and depreciation. Offsetting these advantages are higher pesticide costs, necessary due to greater incidence of weeds, insects, and disease. Yields may be higher, lower, or the same, so there is no distinct advantage or disadvantage. These costs can be calculated and placed on enterprise budgets and allow the analyst to compare systems with different costs and analyze the returns to each system.

In addition to these costs, there are other, external costs which this study does not analyze. The reduction of soil erosion on the no-tillage systems is not taken into account. This must be considered a benefit, not only because of higher, continued productivity of the land, but also because of the reduction of off-farm costs of pollution caused by sedimentation as well as chemical runoff.

The higher application rates of pesticides on the conservation tillage systems may aggravate this latter problem however. Higher rates mean more chemical is present to wash away into streams and groundwater. Another external cost of the conservation systems which is not included in this study is the higher levels of management often required to successfully operate such a system. Only costs associated with field operations were considered.

Use of economic theory and enterprise budgets makes it possible to compare systems with different costs and returns. However, it is difficult to select the system which is best without consideration being given to the risk associated with each. Decision theory and risk will now be discussed.

Decision Theory

Risk and uncertainty influence the efficiency of resource use in agriculture and the decision-making processes of farm managers. Decision theory is applied to risky or uncertain situations, using procedures that have been developed to allow the decision-making process to be systematized.

The risks faced by farmers can be divided into two broad types: business risk and financial risk (Boehlje and Eidman, 1984). Business risk is defined as the inherent uncertainty in the firm independent of the way it is financed. Sonka and Patrick, (1984) delineate five sources of business risk: 1) production or technical risk; 2) market or price risk; 3) technological risk; 4) legal and social risk; and 5) human sources of risk. The first two are considered to be the major sources of risk.

Financial risk is the added variability of net returns to owner's equity that results from the financial obligation associated with debt financing. Financial risk is present due to the inherent risks of using credit. These risks are caused by the uncertainty associated with the cost and availability of credit. In this study, only business risk will be examined.

Modern decision theory is based on the use of personal probabilities. These probabilities are subjective and may differ between individuals, but must be consistent with the axioms and rules of probability to be useful. Individuals' attitudes toward risk are subjective as well and vary depending on the individual's objectives and resources, but can be divided into three types: risk averse, risk neutral, and risk preferring.

Risk averse individuals are generally characterized as more cautious individuals who prefer less risky sources of income and investments. Risk preferrers are more adventuresome with a preference for more risky alternatives compared with those who are risk averse. The risk neutral individual chooses the decision with the highest expected return, regardless of the probabilities associated with alternative levels of gain or loss. Anderson, Dillon, and Hardaker (1977) note that empirical evidence suggests that most decision makers are risk-averse.

Utility Analysis

Utility represents the measure of satisfaction derived by an individual from a situation. In examining risky alternatives, utility analysis provides a means whereby subjective preferences can be quantified and the decision process simplified. A utility function can be used to assign value to the individual's preferences. The decision maker is then able to maximize expected utility consistent with the expressed preferences.

The Expected Utility Hypothesis, based on Bernoulli's principle of rational choice, provides the basis for much of the current theory of decision-making under uncertainty. Bernoulli, in postulating his principle over 200 years ago, provided the means for ranking risky prospects in order of preference, the most preferred being the one with the highest expected utility.

Bernoulli's principle, as found in Anderson, et al (1977), may be stated as follows: a utility function exists for a decision maker whose preferences are consistent with the axioms of ordering and transitivity, continuity, and independence; this function U associates a single real number with any risky prospect and has the following properties:

1) If 'a' is preferred to 'b', then the utility of 'a' is greater than the utility of 'b'.

2) The utility of a risky prospect is its expected utility value which is obtained by evaluating the expected value of the utility function using the probabilities associated with the outcomes.

3) The scale of the function is arbitrary. There is no absolute scale of utility and thus comparisons of utility values between individuals are meaningless.

It was only recently however, with the work of von Neumann and Morgenstern in the 1940's, that the potential of this principle was recognized. They showed that Bernoulli's principle is a logical deduction from the axioms listed above. These are described below:

1) Ordering and Transitivity: A person prefers either prospect 'a' or 'b' or is indifferent between them. In addition, if there exist three risky prospects, 'a', 'b', and 'c', and 'a' is preferred to 'b', and 'b' is preferred to 'c', then 'a' is preferred to 'c'.

2) Continuity: If an individual prefers prospect 'a' to 'b' and 'b' to 'c', then a subjective probability, P(a), exists other than zero or one, that there is indifference between receiving 'b' and a lottery yielding 'a' with probability, P(a), and receiving 'b' and a lottery yielding 'c' with probability, 1-P(a).

3) Independence: If 'a' is preferred to 'b', and 'c' is any other risky prospect, a lottery with 'a' and 'c' will be preferred to a lottery with 'b' and 'c', when the probability of receiving 'a' is equal to the probability of receiving 'b'.

In order to use the expected utility hypothesis, it is necessary to accurately determine the preferences of decision-makers. Problems exist with this in that it is not possible to establish preferences for all the decision makers in an area or community. In addition, problems of inaccuracy may exist in formulating utility functions. Shortcomings in interview procedures, problems in statistical estimation, and individuals' lack of knowledge about their preferences may hinder the estimation process (King and Robison, 1984).

Efficiency Criteria

Some of these problems are overcome by using an efficiency criterion to order choices. Given specified restrictions on the decision maker's preferences, an efficiency criterion provides a partial ordering of choices. The efficiency criterion divides the decision alternatives into two mutually exclusive sets. The efficient set contains the preferred choices of every individual whose preferences conform to the restrictions associated with the criterion. The inefficient set contains the remaining alternatives which are not preferred by any of the decision makers.

An efficiency criterion applies for a particular class of decision makers, as defined by the set of restrictions placed upon their utility functions. If the restrictions are rather general in nature, the criterion can order alternatives, while requiring minimal information about the decision maker's preferences. If enough alternatives are eliminated, decision makers can make a final choice from the efficient alternatives.

The use of efficiency criteria does not solve all problems however. The greater the number of restrictions placed on preferences, the greater the discriminatory power of the criterion. However, this requires more specific information about preferences which may not be available. Fewer restrictions, which are easier to apply to a criterion, may reduce the ability of the criterion to eliminate choices from consideration, making it of little use as a decision making tool.

Included in the category of efficiency criteria are First Degree Stochastic Dominance (FSD), Second Degree Stochastic Dominance (SSD), and Stochastic Dominance With Respect to a Function (SDWRF), which will be discussed below.

Stochastic dominance analysis involves pair-wise comparisons of cumulative distribution functions. First degree stochastic dominance (FSD) is the simplest and most universally applicable efficiency criterion. Since it holds for most decision makers, the usefulness of FSD is somewhat limited, since often, few of the choices are eliminated from consideration.

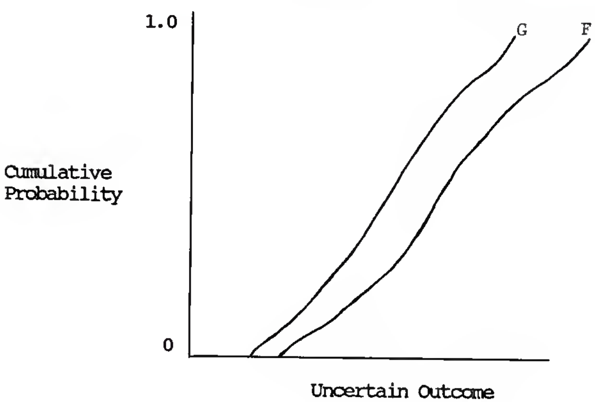
In FSD, marginal utility assumed to be positive, that is, that more is preferred to less. The selection criteria can be stated mathematically or graphically.

Mathematically, the criterion for FSD efficiency can be stated as follows:

> Given two cumulative distribution functions, F(y) and G(y), strategy F can be said to dominate strategy G if:
> $F(y) \leq G(y)$ for all y and if the inequality is strict for some value of y.

Graphically, strategy 'F' dominates strategy 'G' if the cumulative distribution function for 'F' is never above and is below that of 'G' for at least one point. This is illustrated in Figure 3.1, where strategy 'F' dominates strategy 'G'.

Figure 3.1: Illustration of First Degree Stochastic Dominance



Second degree stochastic dominance (SSD) is widely used as an efficiency criterion. It is more discriminating than FSD and holds for all decision makers whose utility functions have a positive, non-increasing slopes at all outcome levels. The SSD criterion is expressed below:

Given two cumulative distribution functions, F(y) and G(y), strategy F dominates strategy G for all who are risk averse if:

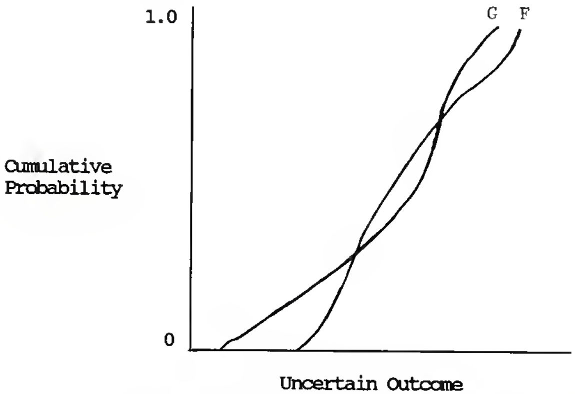
$$\int_{-\infty}^{y} F(y)dy \quad \leq \quad \int_{-\infty}^{y} G(y)dy, \text{ for all values of } y,$$

and if the inequality is strict for some value of y.

SSD is particularly useful in ranking alternative choices given that risk aversion is assumed to be a fairly general form of behavior (Klemme, 1985). This is not always the case however, as King and Robison (1984) note. They cite several studies which indicate that risk preferring behavior may be more prevalent than earlier believed. Also, though SSD is more discriminating than FSD, it may still not reduce the number of efficient alternatives sufficiently. Thus, the need for other criteria.

Second degree stochastic dominance can also be shown graphically. The rule here is that strategy 'F' dominates strategy 'G' if the area under the cumulative distribution function of 'F' never exceeds and is at some point less than the area under the cumulative distribution function of 'G'. This is shown in Figure 3.2, where 'F' dominates 'G'. Note that under FSD, there would be no dominance because 'F' is above 'G' for a time.

Figure 3.2: Illustration of Second Degree Stochastic Dominance



Stochastic dominance with respect to a function (SDWRF) is more discriminating than SSD and also allows greater flexibility in representing preferences. It does require more specific information about the decision maker's preference however (King and Robison, 1984).

The SDWRF criterion orders uncertain choices for decision makers whose absolute risk aversion functions lie within specified lower and upper bounds. This function, the Pratt absolute risk aversion function, is defined as:

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

where $U'(y)$ and $U''(y)$ are the first and second derivatives of a decision maker's utility function, $U(y)$. $R(y)$ is thus the ratio of the rate of change of the slope divided by the slope of the utility function. As such, the value serves as an indicator of the extent to which a decision maker is risk-averse or risk-preferring. A particular value of $R(y)$ can be interpreted as the percent reduction in marginal utility per unit of y. A value of R(y) = .00005 when y is expressed in dollars, would mean that the marginal utility is decreasing at the rate of .005% per dollar. A negative value would indicate increasing marginal utility and increasing risk preference. Positive values indicate increasing risk aversion.

The criterion for SDWRF can be stated as follows:

Cumulative distribution function, F(y), dominates cumulative distribution function, G(y), for all individuals whose absolute risk aversion functions lie between lower and upper bounds R1(y) and R2(y) given a utility function u(y), which minimizes

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

subject to the constraint,

$$R1(y) < -u''(y)/u'(y) < R2(y) \text{ for all values of } y.$$

If the minimum of this difference is positive, then F(y) is unanimously preferred to G(y), and this implies that the expected utility of F(y) is always greater than that of G(y). If the minimum is zero, there is indifference between the two alternatives and cannot be ordered. If the minimum is negative, F(y) is not unanimously preferred, in which case F(y) and G(y) must be reversed in the integral and minimized subject to the constraint to determine whether G(y) is unanimously preferred to F(y).

The major advantage of SDWRF is that it imposes no restrictions on the width or shape of the relevant interval. The lower and upper bounds, $R_1(y)$ and $R_2(y)$, need not be constant and can be placed anywhere in risk-aversion space. Less flexible efficiency criteria, such as FSD and SSD, are more restrictive cases of this general criterion. Both of these require large preference intervals. For FSD, the requirement that marginal utility be positive means that there are no restrictions placed on the decision maker's absolute risk aversion function. The interval for FSD is $R_1(y) = -\infty$ and $R_2(y) = +\infty$. In SSD, the requirement that marginal utility be decreasing as well as positive implies that $R_1(y) = 0$ and $R_2(y) = +\infty$ for all values of y (King and Robison, 1981).

As noted above, stochastic dominance involves pairwise comparisons of the cumulative distribution functions of the specified alternatives. However, if the the alternatives are not mutually exclusive but can be combined to create diversified portfolio strategies, stochastic dominance should be used on a diverse portfolio of alternative strategies rather than on the pure alternatives.

McCarl, Knight, Wilson, and Hastie (1987) provide a test to indicate when dominance of one alternative over another implies dominance over all linear combinations of the two. Correlation coefficients of the strategies are compared to the ratio of their standard errors less a correction for the difference between the means. Pure alternatives may be compared if the correlation coefficient is greater than the ratio, while if it is less, diversification among the strategies should be addressed.

Comparison of Efficiency Criteria

Stochastic dominance techniques are not the only efficiency criteria available to analysts. Two other methods which are used are mean-variance efficiency (EV) and mean-absolute deviation efficiency criterion (MOTAD).

Mean-variance efficiency is the most familiar and most widely used (King and Robison, 1984). MOTAD is an approximation to EV efficiency that can be modeled with linear programming, making it less difficult to use than EV, which uses quadratic programming. Both of these are similar to SSD in the restrictions placed on preferences and are similar in their discriminatory power. Like SSD, both require the decision maker to be risk averse. In addition, the outcome distribution must be normal. If these conditions are met, the efficient set will be identical for each.

Differences between stochastic dominance and other techniques include the use of mathematical programming by EV and MOTAD and the use of means and variances of probability distributions which are generally easier to use. Stochastic dominance involves pair-wise comparisons between alternatives which cannot be incorporated in mathematical models easily, though King and Robison (1984) cite Markowitz with developing a linear programming algorithm that identified efficient strategies under SSD.

Problems of MOTAD and EV include the assumption of risk aversion by the decision maker and low discriminatory power. In addition, the assumption of a normal distribution causes problems because much data is not normally distributed.

Analyses of efficiency criteria have been conducted by King and Robison (1984), and Lee, Brown, and Lovejoy (1985). In the first case, when strategy rankings for FSD, SSD, EV, MOTAD, and SDWRF were compared, it was found that FSD was ineffective in discriminating between alternatives and that the efficient sets of SSD, EV, and MOTAD were identical though the distributions were not normal. SDWRF was used for two preference intervals with the efficient set being much smaller in one, indicating its greater discriminatory power, and only slightly smaller in the other.

In the study by Lee, et al, SSD and EV techniques were compared using subjective and objective income distributions for farmers deciding on the adoption of reduced tillage practices in Indiana. Objective distributions were found by surveying farmers and collecting data which was used to estimate costs and prices which were then used to develop a linear programming model for each farm from which "objective" income distributions could be generated. Subjective distributions were determined by interviewing the same farmers and asking them to distribute probabilities along an income continuum for each cropping system, conventional tillage and reduced tillage. The subjectivity of this is found in manner in which each farmer distributes the probabilities, with each using their own criteria to determine the probabilities of income.

It was found that EV analysis was superior to SSD when objective distributions were used. When using subjective distributions, SSD was better able to predict farmer response. The conclusion was that if objective data was available, EV analysis might be preferable to stochastic dominance techniques.

CHAPTER FOUR

PROCEDURE AND ASSUMPTIONS

Outline of Procedures

Stochastic dominance techniques are used to compare the variations of net returns to management of different cropping systems based on a representative case farm in West Central Kansas. Details of the representative farm are based on 1985 Kansas Farm Management Association data for this region.

Net return distributions for ten different crop-tillage systems are examined in this study. Each system represents a unique combination of inputs and operations used in producing a crop. The ten crop-tillage systems considered in this study consist of five different rotations of wheat and grain sorghum, grown continuously, in crop-fallow systems, and in rotation with each other on two tillage systems, conventional tillage and no-tillage. These systems are based on actual cropping practices at the Fort Hays Branch Experiment Station for the years 1976 through 1986.

Enterprise budgets are used in determining the costs and returns of each crop-tillage system and are an important part of the analysis. Three primary steps are included in formulating these budgets:
1) identifying the operations and inputs which comprise each system, including the timing of tillage and planting practices and application of inputs; 2) determination of the machinery requirement for each system; and 3) actual formulation of the enterprise budget based upon technical requirements and economic values. These are further discussed below.

Identification of the typical tillage operations and operating inputs used is necessary for determining a technically feasible crop-tillage system. Typical tillage practices are those which are generally recognized as common for that type of system. Operating inputs include the variable costs of production such as seed, fertilizer, fuel and oil, or herbicides.

When determining machinery requirements, consideration must be given to the timing as well as the technical requirements of each field operation. A machinery complement can be selected based on the tillage requirements of each system. Farm size, tillage and planting constraints, and available field workdays are information used in determining tractor and implement sizes using a worksheet by Schrock (1976).

In formulating the enterprise budgets, the variable costs of labor, fuel, oil, and machinery repairs are calculated for each field operation in each crop-tillage system. Costs for seed, fertilizer, and pesticides are determined also. Fixed costs of insurance, interest, and depreciation are determined for each implement and land costs for land which is owned and rented are calculated. The variable costs of the operating inputs is added with the fixed costs to derive the annual total costs of production for each system. Annual returns are calculated using yield and price data and an annual net return is determined by subtracting the total annual costs from the annual returns.

Establishing Farm Size and Tenure

Kansas Farm Management Association data were used in establishing the size and the tenure arrangements of the representative farm. No data were available for Ellis County specifically, so a weighted average of 130 predominantly dryland farms in five nearby counties was used. Figure 4.1 shows the Kansas Farm Management Associations. Shaded portions represent the counties used in this study. They are Barton, Hodgeman, Lincoln, Osborne, and Smith counties.

The average farm size was 1686 acres of which 1085 acres was cropland. This figure was rounded to 1100 acres for ease of calculation. Owned land represented 33.40 % and rented land accounted for 66.60 %. These were rounded to 33.33 % (1/3) and 66.67% (2/3). Thus, owned land constituted 366.7 acres and rented land was 733.3 acres of the total 1100 acres.

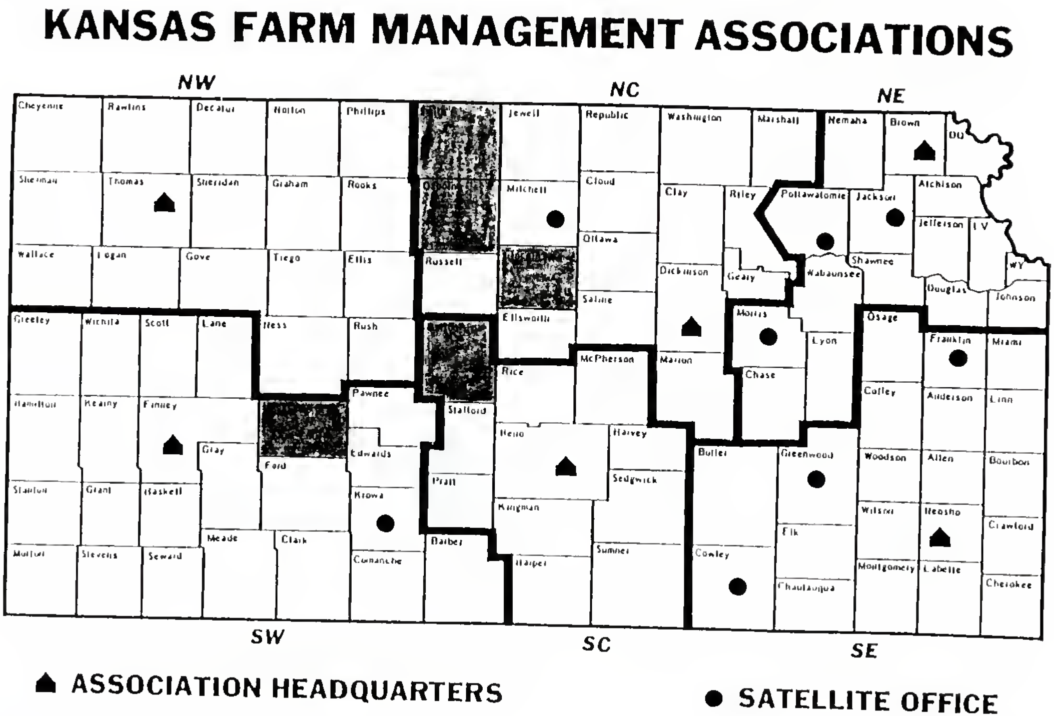
<u>Crop-Tillage Systems</u>

Technical information on cropping practices and yield data were obtained from the Fort Hays Branch Experiment Station. A study examining wheat and grain sorghum rotations under conventional and no-tillage operations has been conducted each year beginning in 1976. Ten crop-tillage systems are studied. These are listed in Table 4.1.

Table 4.1: Cropping Systems

1.	Conventional Tillage Wheat-Fallow	CVWF
2.	No-Tillage Wheat-Fallow	NTWF
3.	Conventional Tillage Continuous Wheat	CVWW
4.	No-Tillage Continuous Wheat	NTWW
5.	Conventional Tillage Continuous Grain Sorghum	CVSS
6.	No-Tillage Continuous Grain Sorghum	NTSS
7.	Conventional Tillage Grain Sorghum-Fallow	CVSF
8.	No-Tillage Grain Sorghum-Fallow	NTSF
9.	Conventional Tillage Wheat-Grain Sorghum-Fallow	CVWSF
10.	No-Tillage Wheat-Grain Sorghum-Fallow	NTWSF

FIGURE 4.1: Kansas Farm Management Associations - County Data Used in Study.



Tillage Systems. In conventional tillage, the soil is mixed or inverted using a plow, disk, or other primary tillage implement. The soil is prepared for planting using secondary tillage which smooths and packs the ground. In this study, conventional tillage consists of primary tillage using a V-blade or disk and secondary tillage with a rodweeder in the wheat rotations prior to wheat planting. A disk is used in seedbed preparation in sorghum systems. Cultivation occurs during the growing season in the grain sorghum systems. Some herbicides are used in each system except the wheat-fallow system. Sorghum requires the use of more herbicides in supplementing weed control by tillage.

In no-tillage, weed control is achieved exclusively through the application of herbicides in these systems. There are no tillage operations which take place. The crop is planted directly into the remaining residue of the previous crop. The only operations are planting and herbicide application.

Cropping Systems. Differences in the length of fallow period are a major distinction between the various systems. In the wheat-fallow systems, a 15 month fallow period occurs between harvest of one crop and the planting of the next. Wheat is planted in September, harvested the following July, then V-blade tillage in the conventional tillage system or herbicides in the no-tillage system are used to maintain a fallow for approximately 15 months until wheat is again planted in late September of the next year. One-half of the cropland is planted to wheat and one-half is in fallow each year. Tables 4.2 and 4.3 show the field operations for CVWF and NTWF.

Table 4.2: FIELD OPERATIONS REQUIRED IN CROPPING SYSTEMS: CVWF
1100 acres: 550 acres wheat, 550 acres fallow

OPERATION	DATE (APPR.)	YEAR	AMOUNT	130 HP TRACTOR	110 HP TRACTOR	ANNUAL ACRES
V-Blade	June 5	I	---	22 ft.	18 ft.	550
V-Blade	July 10	I	---	22 ft.	18 ft.	550
Apply fertilizer	July 10	I	40 lbs.	Custom Hired		550
V-Blade	August 20	I	---	22 ft.	18 ft.	550
Rodweeder	Sept. 15	I	---	25 ft.		550
Plant wheat	Sept. 25	I	---	24 ft.		550
Harvest wheat	July 1	II	---	Custom Hired		550
V-Blade	July 20	II	---	22 ft.	18 ft.	550
V-Blade	Oct. 15	II	---	22 ft.	18 ft.	550
					TOTAL ACREAGE	4950

Table 4.3: FIELD OPERATIONS REQUIRED IN CROPPING SYSTEMS: NTWF
1100 acres: 550 acres wheat, 550 acres fallow

OPERATION	DATE (APPR.)	YEAR	AMOUNT	130 HP TRACTOR	ANNUAL ACRES
Apply herbicide	May 5	I		40 ft.	550
Glean			3/8 oz.		
Bladex			2 lbs.		
Apply fertilizer	May 5	I	40 lbs.	Custom Hired	550
Apply herbicide	August 10	I		40 ft.	550
Roundup			16 oz.		
2,4-D			1/2 lb.		
Plant wheat	Sept. 25	I	---	24 ft.	550
Harvest wheat	July 1	II	---	Custom hired	550
Apply herbicide (50%)	July 10	II		40 ft.	275
Atrazine			1 lb.		
Roundup			16 oz.		
				TOTAL ACREAGE	3025

The continuous wheat system has the entire acreage planted to a crop each year. Wheat is planted in September, harvested in July of the next year, and planted again to wheat in September. The conventional system uses a V-blade and disk to control weeds and prepare for planting in the three month period between harvest and planting. Herbicides are used in the no-till system for this purpose. The field operations for CVWW and NTWW are shown in Tables 4.4 and 4.5 respectively.

Continuous sorghum, like continuous wheat, produces a crop each year. Herbicides are applied prior to planting in both systems. A disk is used to prepare the seedbed in the conventional system. Sorghum is planted approximately June 1. Herbicides are used for weed control in the no-till system while cultivation between the row is used in the conventional system. Insecticide is applied in August. The sorghum is harvested in October. Atrazine is applied following harvest in the no-till system for early weed control in the spring. A November V-blade operation is performed on the conventional system. Tables 4.6 and 4.7 gives the field operations for CVSS and NTSS.

The sorghum-fallow system utilizes one-half of the cropland for growing the crop and the other half for fallow. During the fallow period, V-blade tillage is used to control weeds in the conventional system. Herbicides are again used in the no-tillage system. In the spring prior to planting, herbicides are applied in both systems. A disk and rodweeder are used in seedbed preparation in the conventional system with cultivation during the growing season. Sorghum is planted on about June 1 and harvested in October and the ground is left fallow

Table 4.4: FIELD OPERATIONS REQUIRED IN CROPPING SYSTEMS: CVWW
1100 acres: 1100 acres wheat

OPERATION	DATE (APPR.)	YEAR	AMOUNT	170 HP TRACTOR	170 HP TRACTOR	ANNUAL ACRES
Harvest wheat	July 1	1	—	Custom hired		1100
V-Blade	July 15	1	—	22 ft.	22 ft.	1100
V-Blade	August 15	1	—	22 ft.	22 ft.	1100
Apply fertilizer	August 15	1	40 lbs.	Custom Hired		1100
Disk	Sept. 20	1	—	24 ft.	24 ft.	1100
Plant wheat	Sept. 25	1	—	40 ft.		1100
					TOTAL ACREAGE	6600

Table 4.5: FIELD OPERATIONS REQUIRED IN CROPPING SYSTEMS: NTWW
1100 acres: 1100 acres wheat

OPERATION	DATE (APPR.)	YEAR	AMOUNT	170 HP TRACTOR	ANNUAL ACRES
Harvest wheat	July 1	1	—	Custom hired	1100
Apply herbicide	July 10	1		60 ft.	1100
Roundup			12 oz.		
Apply herbicide	August 10	1		60 ft.	1100
Roundup			12 oz.		
Glean			1/4 oz.		
Apply fertilizer	August 15	1	40 lbs.	Custom Hired	1100
Plant wheat	Sept. 25	1	—	40 ft.	1100
				TOTAL ACREAGE	5500

Table 4.6: FIELD OPERATIONS REQUIRED IN CROPPING SYSTEMS: CVSS
1100 acres: 1100 acres sorghum

OPERATION	DATE (APP)	YEAR	AMOUNT	170 HP TRACTOR	130 HP TRACTOR	110 HP TRACTOR	ANNUAL ACRES
Spray herbicide	April 15	I			60 ft.		1100
Propazine			2 lbs.				
Apply fertilizer	April 15	I	40 lbs.	Custom Hired			1100
Disk	May 5	I	---	24 ft.	18 ft.		1100
Disk	May 25	I	---	24 ft.	18 ft.		1100
Plant sorghum	June 1	I	---	30 ft.	30 ft.		1100
Cultivate	July 10	I	---		30 ft.	15 ft.	1100
Spray insecticide	August 1	1			60 ft.		1100
Parathion			1/2 lb.				
Harvest sorghum	Oct. 20	I	---	Custom hired			1100
V-Blade	Nov. 10	I	---		22 ft.	18 ft.	1100
						ANNUAL ACREAGE	9900

Table 4.7: FIELD OPERATIONS REQUIRED IN CROPPING SYSTEMS: NTSS
1100 acres: 1100 acres sorghum

OPERATION	DATE (APPR.)	YEAR	AMOUNT	130 HP TRACTOR	130 HP TRACTOR	ANNUAL ACRES
Apply herbicide	April 15	I		60 ft.	30 ft.	1100
Bladex			2 lbs.			
Apply fertilizer	April 15	1	40 lbs.	Custom Hired		1100
Apply herbicide	May 20	1		60 ft.	30 ft.	1100
Roundup			12 oz.			
Dual			1.5 lbs.			
Plant sorghum	June 1	I		30 ft.	30 ft.	1100
Apply insecticide (50%)	August 5	I		60 ft.	30 ft.	550
Parathion			1/2 lb.			
Harvest sorghum	Oct. 20	1		Custom hired		1100
Apply herbicide	Oct. 25	1		60 ft.	30 ft.	1100
Atrazine			1 lb.			
					ANNUAL ACREAGE	7150

for 19 months before sorghum is again planted. The field operations for CVSF and NTSF are summarized in Tables 4.8 and 4.9.

The wheat-grain sorghum-fallow rotation has been examined in studies at experiment stations (Nilson, et al, 1985). In this system, wheat is grown on one-third of the land, grain sorghum on one-third, and one-third is fallow. In the conventional system, wheat is planted in September, harvested in July of the second year. Atrazine is applied after harvest for weed control and supplemented by tillage in the fall. The ground is idle for 11 months. In the third year, a disk is used to prepare for planting sorghum. Sorghum is planted in June, cultivated in July, and harvested in October. Another 11 month fallow period follows until wheat is again planted in September. The no-tillage system follows the same basic time-frame, using herbicides in place of tillage. Field operations for CVWSF and NTWSF are included in Table 4.10 and Table 4.11, respectively.

Machine Complement Selection

A unique machinery complement is required for each crop-tillage system in order to provide the required tillage operations. Each operation requires the use of one tractor and one implement. Tractor size must be matched to implement size for each operation. This study develops a machinery complement for each system based on the needs of that system.

Schrock (1976) lists four steps in determining tractor size and implement width needed: 1) identify the critical job; 2) estimate the time available to do the job; 3) size the implement needed; and 4) estimate the power requirements of the tillage implement to size the

Table 4.8: FIELD OPERATIONS REQUIRED IN CROPPING SYSTEMS: CVSF
1100 acres : 550 sorghum, 550 fallow

OPERATION	DATE (APPR.)	YEAR	AMOUNT	130 HP TRACTOR	110 HP TRACTOR	ANNUAL ACRES
V-Blade	June 5	1		22 ft.	18 ft.	550
V-Blade	July 15	I		22 ft.	18 ft.	550
V-Blade	Sept. 1	I		22 ft.	18 ft.	550
V-Blade	Nov. 15	1		22 ft.	18 ft.	550
Apply fertilizer	Nov. 15	I	40 lbs.	Custom Hired		550
Apply herbicide Propazine	April 15	11	2 lbs.	40 ft.		550
Disk	May 10	1I		18 ft.	15 ft.	550
Rodweeder	May 20	11		25 ft.		550
Plant sorghum	June 1	1I		30 ft.		550
Cultivate	July 10	11		30 ft.		550
Harvest sorghum	Oct. 20	1I		Custom hired		550
					ANNUAL ACREAGE	6050

Table 4.9: FIELD OPERATIONS REQUIRED IN CROPPING SYSTEMS: NTSF
1100 acres: 550 acres sorghum, 550 acres fallow

OPERATION	DATE (APPR.)	YEAR	AMOUNT	130 HP TRACTOR	ANNUAL ACRES
Spray herbicide	April 15	I		60 ft.	550
Atrazine			1 lb.		
Spray herbicide	June 15	I		60 ft.	550
Roundup			12 oz.		
Spray herbicide	August 5	I		60 ft.	550
Roundup			12 oz.		
Spray herbicide	Nov. 1	I		60 ft.	550
Atrazine			1 lb.		
Apply fertilizer	Nov. 15	I	40 lbs.	Custom Hired	550
Spray herbicide	April 15	II		60 ft.	550
Bladex			2 lb.		
Spray herbicide	May 20	II		60 ft.	550
Roundup			12 oz.		
Dual			2 lb.		
Plant sorghum	June 1	II		30 ft.	550
Harvest sorghum	Oct. 20	II		Custom hired	550
				ANNUAL ACREAGE	4950

Table 4.10: FIELD OPERATIONS REQUIRED IN CROPPING SYSTEMS: CVWSF
1100 acres: 366.67 acres wheat, 366.67 acres sorghum, 366.67 acres fallow

OPERATION	DATE (APPR.)	YEAR	AMOUNT	170 HP TRACTOR	110 HP TRACTOR	ANNUAL ACRES
V-Blade	June 10	I		26 ft.		366.67
V-Blade	July 15	I		26 ft.		366.67
Apply fertilizer	July 15	I		Custom hired		366.67
Rodweeder	Sept. 1	I		25 ft.		366.67
Plant wheat	Sept. 25	I			16 ft.	366.67
Harvest wheat	July 1	II		Custom hired		366.67
Spray herbicide Atrazine	July 10	II	2 lbs.		30 ft.	366.67
V-Blade	August 5	II		26 ft.		366.67
V-Blade	Nov. 10	II		26 ft.		366.67
Disk	May 25	III			15 ft.	366.67
Plant sorghum	June 1	III			20 ft.	366.67
Cultivate	July 10	III			20 ft.	366.67
Harvest sorghum	Oct. 20	III		Custom hired		366.67
Apply fertilizer	Nov. 10	III		Custom hired		366.67
					TOTAL ACREAGE	5133.33

Table 4.11: FIELD OPERATIONS REQUIRED IN CROPPING SYSTEMS: NTWSF
1100 acres: 366.67 acres wheat, 366.67 acres sorghum, 366.67 acres fallow

OPERATION	DATE (APPR.)	YEAR	AMOUNT	110 HP TRACTOR	ANNUAL ACRES
Apply herbicide	May 5	I		30 ft.	366.67
Glean			3/8 oz.		
Bladex			2 lbs.		
Apply fertilizer	May 5	I	40 lbs.	Custom Hired	366.67
Apply herbicide	August 10	I		30 ft.	366.67
Roundup			16 oz.		
2,4-D			1/2 lb.		
Plant wheat	Sept. 25	I		16 ft.	366.67
Harvest wheat	July 1	II		Custom Hired	366.67
Apply herbicide (50%)	July 10	II		30 ft.	183.33
Roundup			16 oz.		
Atrazine			1 lb.		
Apply herbicide	April 15	III		30 ft.	366.67
Bladex			2 lbs.		
Apply fertilizer	April 15	III	40 lbs.	Custom hired	366.67
Apply herbicide	May 20	III		30 ft.	366.67
Roundup			12 oz.		
Dual			2 lbs.		
Plant sorghum	June 1	III		20 ft.	366.67
Harvest sorghum	Oct. 20	III	Custom hired		366.67
				TOTAL ACREAGE	3850.00

tractor needed. Appendices A through E contain the worksheets used in determining tractor and implement size.

Identify the Critical Job. Tractors and implements should have sufficient capacity to complete field operations within the optimal time period. Timeliness, especially at planting, is important because it can impact crop yields and quality. Recommendations from agronomists were used to establish critical periods. Optimal planting dates for wheat in this region are September 10 to October 20, while the optimal range for grain sorghum is May 10 to June 20 (Shroyer, 1986, and Peterson, 1981).

The most limiting field operation determines the size of the tractor. The tractor(s) must be large enough to allow planting and tillage operations to occur within the optimal time period. Timeliness in tillage operations is also important in order to achieve the goal of weed control. Allowing weeds to become too large causes excessive moisture loss and difficulty in control.

Planting operations were most often limiting in these systems, though disking and V-blade operations determined tractor size in some. Implements are perhaps a bit oversized to avoid problems with time constraints. This allows the analysis to better examine yield and price risk by removing this as a source of variation. Since harvesting was assumed to be custom hired, there was no selection of harvesting equipment.

Estimate the time Available to do the Job. In estimating the time available to do the job, the operator must have some idea of the number of days that weather will permit field operations and how many hours each day are available. Knowledge of these permits the operator to calculate the total time that is available to complete the operation within the optimal time period and thus it is possible to determine the necessary tractor and implement size.

Buller, et al, (1976) compiled a list of field workdays available for several locations in Kansas (Table 4.12). Field workdays refer to days when the soil moisture content is satisfactory for field operations to be performed. This list is based on the frequency of occurrence in a given year and involves using a confidence level of that occurrence. For this study, an 85% confidence level is used. The 85% level means that in 85% of the years, there should be at least the given number of days suitable for field operations. This will cause implement size to be somewhat larger than would be needed if a smaller confidence level were used and further eliminates the possibility of timeliness problems. The percent is calculated by dividing days available in a period by total days in that period.

Table 4.12: Minimum Number of Field Workdays Available at Hays, Kansas using 85% confidence level.

DATE	Days Available	Percent Available
April 1-15	9	60%
April 16-30	8	53%
May 1-15	7	47%
May 16-31	7	47%
June 1-15	3	20%
June 16-30	7	47%
July 1-15	7	47%
July 16-31	8	53%
August 1-15	7	47%
August 16-31	9	60%
September 1-15	7	47%
September 16-30	5	33%
October 1-15	6	40%
October 16-31	9	60%

To estimate available working days for a given operation, the desired time period in which the operation is to be performed must be known. Available working days are then determined by multiplying the number of days in the desired period by the percentage in the table. As an example, sorghum planting occurs between May 26 and June 15. Thus, there are five days in the interval May 16-31 and fifteen days in the interval June 1-15. Multiplying five by 47% yields 2.4 days available in the latter part of May and fifteen multiplied by 20% provides 3 days for a total of 5.4 working days available during this time period.

The number of work hours per day used in this study was ten. This is the time spent in the field and does not include time spent on maintenance, fueling, transport, or other activities. This number is perhaps low for summertime, when daylength is longer, but again, it avoids creating a problem with timeliness by oversizing the machinery if anything. The total time available is determined by multiplying the field work days by the number of work hours per day.

It is then necessary to schedule the operations and determine if there are any that overlap, requiring more or larger equipment. This occurs in the conventional continuous sorghum system during the planting season where planting and disking overlap and an additional tractor is required.

<u>Sizing the Machinery.</u> Field capacity in acres per hour is determined by dividing the total acres by the total time available. The formula below then allows calculation of implement width:

Equation (1)

$$W = \frac{FC \times 8.25}{S \times FE}$$

where W is the width of the implement in feet, FC is the field capacity in acres per hour, S is operating speed in miles per hour, and FE is field efficiency expressed as a percent. Speeds and field efficiencies were determined from Schrock, (1976) and are summarized in Table 4.13.

Table 4.13: Approximate Speeds and Field Efficiencies

Field Operation	Speed (mph)	Field efficiency
V-Blade	5.0	82.5%
Rodweeder	5.5	82.5%
Disk	5.5	85.0%
Row crop cultivator	4.5	72.5%
Boom sprayer	6.0	60.0%
Hoedrill	5.0	72.5%
Conventional row crop planter	4.0	67.5%
No till row crop planter	4.0	67.5%

Estimate Power Requirements. The size of the tractor must be matched to the size of the implement. Once the implement width is determined, it is possible to determine tractor size. The PTO horsepower requirement for tractors is calculated by multiplying the implement width by the horsepower requirement per foot of width. Schrock, (1976) supplies approximate tractor power requirements for tillage implements. Table 4.14 includes power requirements for each implement used in the study and the maximum width allowable and actual size of implement for each tractor. Appendix F contains the equipment complement for each system.

Table 4.14: EQUIPMENT COMPLEMENT FOR REPRESENTATIVE FARM

Implement	PTO HP per foot	Max. Width 170 HP	Size in Study	Max. Width 130 HP	Size in Study	Max. Width 110 HP	Size in Study
Disk	7.0	24.3	24.0	18.6	18.0	15.7	15.0
V-Blade	5.5	30.9	26.0	23.6	22.0	20.0	18.0
Rodweeder	4.5	37.8	25.0	28.9	25.0	24.4	----
Hoedrill	4.25	40.0	40.0	30.6	24.0	25.9	16.0
Conventional planter	4.0	42.5	30.0	32.5	30.0	27.5	20.0
No-till planter	4.0	42.5	----	32.5	30.0	27.5	20.0
Row-crop cultivator	4.0	42.5	----	32.5	30.0	27.5	20.0

Yields and Prices. Crop prices are the annual season average from the central district of the Kansas Crop and Livestock Reporting Service (see Appendix G). Yield data for wheat and grain sorghum in each tillage system were obtained from the Fort Hays Branch Experiment Station for the eleven year period that the tillage study has been conducted, 1976-1986. Soil moisture data for each system prior to planting were also obtained from the experiment station. Yield and moisture data were analyzed with analysis of variance procedure using Duncan's multiple range test to determine if the mean yield or mean soil moisture percentage were significantly different. A 95% confidence level was used. Results are discussed in Chapter 5.

Enterprise Budgets

Enterprise budgets are used to summarize the annual operating expenses and machinery costs of each system and to provide a projection of expected revenue, making it possible to compare costs and returns of alternative cropping systems.

Several stages are involved in constructing an enterprise budget.

Labor, fuel, oil, and equipment repair costs per acre must be determined based on actual field operations. Annual depreciation, insurance, and interest costs must be determined for the machinery complement on a per acre basis as well. Finally, costs associated with the cropping system are determined. These would include seed, fertilizer, and chemical costs, custom hire expense, land ownership costs and share rent costs.

These can then be summarized in the traditional enterprise budget format with variable costs and fixed costs shown separately. Gross returns can be calculated and net returns to management can be estimated. Net returns to management are shown on the last line of the budget. Table 4.15 is an example of an enterprise budget used in this analysis. Appendices J,K, and M show worksheets used in constructing the enterprise budgets for each system. Appendix L contains the enterprise budgets for each crop-tillage system. A summary of each item in the budgets is:

Labor Cost (1)[1] per acre is the sum of the per acre labor costs of all field operations. Labor is assumed to be provided by the operator unless more than one operation is required simultaneously. The cost per field operation is equal to the wage rate per hour divided by the field capacity in acres per hour, multiplied by the number of acres covered by this operation divided by the total crop acres. The example below calculates the labor cost per acre of the V-blade operation using the 130 HP tractor and the 22 foot V-blade unit in the CVWF system. A 110

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[1]Numbers in parentheses indicate the line on the enterprise budget summary where this information is found.

HP tractor and 18 foot V-blade are also used in the V-blade operation in this system.

Equation (2)

Labor Cost = (($/Hr / Acres/Hr) x Acres Covered) / Total Acres

$0.25 = (($6.00 / 13.3) x 302.5) / 550

Labor is valued at $6.00 per hour (Langemeier and Krause, 1984). In this example, the V-blade has a field capacity of 13.3 acres per hour. Of the 550 wheat acres in the CVWF system, this tractor-implement unit covers 55%, or 302.5 acres. The remaining 45%, or 247.5 acres, is covered by the other tractor and V-blade. Total acres refers to the total acres of the specific crop for which the operation is being performed, in this case, 550 acres. For the continuous systems, this number is 1100 acres and for the wheat-sorghum-fallow systems it is 366.7 acres, the amount of wheat, sorghum, or fallow land on which the operation is being performed.

Seed Expense (2) is calculated using the actual seeding rate in pounds per acre multiplied by the cost per pound of seed. The seeding rate for wheat is 45 pounds per acre and the rate for grain sorghum was 4 pounds per acre. Seed cost for wheat was $0.10 per pound and was $0.70 per pound for grain sorghum. The cost per acre for wheat is $4.50 and for grain sorghum is $2.80.

Herbicide Cost (3), Insecticide Cost (4), and Fertilizer Cost (5) are based on the actual application rates used at the experiment station. In this study, these materials are assumed to be applied by the operator. It is further assumed that on rented land, the landlord

Table 4.15: Sample Enterprise Budget
Conventional Wheat-Fallow (CVWF)
Year I: Fallow and Plant Wheat; Year 2: Harvest Wheat

	$/ Bushel	Total	Cash
VARIABLE COSTS PER ACRE			
1. Labor ($6.00/hr. * .552 hours)	0.114	$3.31	$1.25
2. Seed	0.154	$4.50	$4.50
3. Herbicide	0.000	$0.00	$0.00
4. Insecticide	0.000	$0.00	$0.00
5. Fertilizer	0.153	$4.45	$4.45
6. Fuel ($0.95/gallon)	0.151	$4.40	$4.40
7. Oil (.15 * fuel)	0.023	$0.66	$0.66
8. Equipment repair	0.192	$5.60	$5.60
9. Custom Hire	0.672	$19.60	$19.60
10. Interest (1/2 Variable Costs @ 14%)	0.109	$3.19	$1.82
A. TOTAL VARIABLE COSTS (Owned land)	$1.57	$45.70	$42.28
TOTAL VARIABLE COSTS (Rented land)**	$1.52	$44.11	$40.68
FIXED COSTS PER ACRE			
11. Real estate taxes ($.50/$100)	0.146	$4.25	$4.25
12. Interest on land	1.750	$51.00	$34.68
13. Share rent (Returns * .333)	1.056	$30.77	$30.77
14. Depreciation on machinery	0.366	$10.67	$0.00
15. Interest on machinery	0.368	$10.73	$3.57
16. Insurance/Housing	0.052	$1.53	$1.53
B. TOTAL FIXED COSTS (Owned land)	$2.68	$78.18	$44.03
TOTAL FIXED COSTS (Rented land)	$1.84	$53.70	$35.87
C. TOTAL COSTS PER ACRE (Owned land)	$4.25	$123.88	$86.31
TOTAL COSTS PER ACRE (Rented land)	$3.36	$97.81	$76.55
D. YIELD PER ACRE		29.15	
E. PRICE / BUSHEL		$3.17	
F. RETURNS PER ACRE (Row D * Row E)		$92.41	
G. RETURNS OVER VARIABLE COSTS (AVE.)	$1.53	$47.76	$51.19
H. RETURNS OVER TOTAL COSTS (Owned land)	($1.08)	($31.48)	$6.10
I. RETURNS OVER TOTAL COSTS (Rented land)	($0.19)	($5.41)	$15.85
J. ANNUAL NET RETURNS PER ACRE (AVE.)		($14.09)	$12.60
K. NET RETURNS TO MANAGEMENT (Row J * Crop Acres)		($7,749.02)	$6,931.99

** Assumes landlord pays 1/3 of fertilizer, herbicide, insecticide cost on rented land.

will pay one third of the chemical costs and the tenant will pay the remaining two-thirds.

The per acre cost is determined by multiplying the application rate by the per unit price of the input. Prices were obtained from local suppliers and are the average of several retail dealers. These are given in Appendix G.

The worksheets used in calculating the chemical costs for each system are included in Appendix J. Herbicide is applied in each system except CVWF. Weed problems exist primarily in the no-till systems though herbicides are used in the conventional systems as well. Perennial grassy weeds in the wheat systems, particularly in the wheat-sorghum-fallow rotations, and annual grasses, including downy bromegrass, in the sorghum systems are the biggest problems. Bladex and Dual are used in the sorghum systems for control of grassy weeds and triazine herbicides are used to control annual broadleaf weeds. In the wheat systems, Glean is used for broadleaf weed control. Roundup, a non-selective herbicide, is used during fallow periods for control of weeds in both wheat and sorghum systems, particularly to control perennial weeds in wheat stubble.

Parathion is the only insecticide used and is applied for control of greenbugs in the continuous sorghum rotations. Forty pounds of actual nitrogen per acre is applied on both wheat and grain sorghum plots for each crop. Fallow plots are not fertilized.

Fuel Cost (6) per acre is the sum of the cost of each field operation. The cost per acre for each operation is equal to the price of fuel ($/gal) multiplied by fuel use in gallons per acre times the number of acres covered by the operation divided by the total crop acres. The fuel price used is $0.95 per gallon. Fuel consumption in liters per hectare was obtained from Schrock, (1985) and converted to gallons per acre by dividing by 9.353. Equation (3) provides an example of the calculation of fuel costs per acre for the V-blade operation in the CVWF system:

Equation (3)

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Fuel Cost = (($/gal x (liter/ha /9.353) x Acres Covered) / Total Acres
    $0.39 = (($0.95 x    (7.0   /9.353) x     302.5)     /   550
```

In the above example, the tractor uses 7.0 liters per hectare, which converts to .749 gallons per acre. This tractor-implement unit covers 302.5 acres of the total 550 annual crop acres in this system as before. Fuel cost per acre for this operation is $0.39.

<u>Oil Cost</u> (7) is assumed to be 15% of the fuel cost (Kletke, 1977). In this example, 15% of $0.39 is $0.06. The sum of the individual field operations is the total per acre cost for the system.

<u>Repair Cost</u> (8) per acre is estimated based on the number of hours the tractor and tillage implement are used in each field operation. Rotz, (1985) provides a model for predicting repair costs based on initial list price and machine age in thousands of hours of machine use, using two repair coefficients, RC1 and RC2.

Repair and maintenance costs tend to increase with machine age. A model for repair and maintenance cost must accurately predict the trend in costs over the life of the machine. Not all machines increase in costs at the same rate however. Some tend to be more uniform over their life than others.

Rotz assigns to each machine a proportional coefficient (RC1) to describe the magnitude of the repair costs and an exponential coefficient (RC2) to describe the distribution of costs throughout the machine's life. Values for these parameters were determined by considering data on machinery life and repair costs gathered over a number of years in various studies. Basing the model on hours of accumulated use rather than on field area covered obtains more realistic costs across a wide range of machine sizes and ages.

Since repair and maintenance costs change with age of the machine, it is necessary to determine each machine's age. This study assumes that all existing machinery to be at an age equal to one-half of its depreciable life. Existing machinery is defined to be all machinery found in the conventional wheat-fallow system. This includes V-blades, rodweeders, and hoedrills. Previously non-existing machinery includes planters, cultivators, disks, and sprayers and is assumed to be purchased new.

Average repair cost per hour of use is used in computing repair costs per acre. Since both a tractor and implement are used together in a field operation, it is necessary to calculate repair costs for both. In the example below, Equation (4) determines the implement repair cost per hour, while Equation (5) calculates the hourly repair cost for the tractor. Total repair costs per hour are determined by summing the results of Equations (4) and (5) as shown in Equation (6). Repair costs per acre for this V-blade operation on the CVWF are then calculated in Equation (7).

Equation (4) Implement Repair Per Hour

= (List price x RC1 x (Life/1000)^RC2) / Life

=($9625 x 0.38 x (2000/1000)^1.4)/2000
= $4.83

Equation (5) Tractor Repair Per Hour

= (List price x RC1 x (Life/1000)^RC2) / Life

= ($48600 x 0.01 x (10000/1000)^2) / 10000
= $5.44

Equation (6) Total Repairs Per Hour

= Implement Repair Per Hour + Tractor Repair Per Hour

= $4.83 + $5.44
= $10.27

Equation (7) Total Repairs Per Acre

= Total Repairs Per Hour x Hours Use / Total Crop Acres

= $10.27 x 22.7 / 550
= $0.42

List price is the 1986 list price of the machine. Equipment list prices are shown in Appendix F. Life is the estimated life of the machine in hours, and RC1 and RC2 are the repair cost coefficients. Hours Use is the actual field time of the tractor-implement combination. Total Crop Acres again represents acres on which a crop is grown annually. In this example, this number is 550 acres, which is correct for the crop-fallow systems. The value for the continuous systems is 1100 acres and it is 366.7 acres for the wheat-sorghum-fallow systems as noted above in the section on labor costs. Appendix H contains the estimated life and repair factors for implements used in this study.

Custom Hire (9) includes harvesting and fertilizer application costs associated with each system. Custom harvest rates were obtained from Johnson, (1987). Rates for wheat are $12.00 per acre, with a premium of $0.12 per bushel for yields over 20 bushels per acre. Grain sorghum rates are $13.00 per acre and a $0.12 premium for yield over 30 bushels per acre. Trucking rates are $0.12 per bushel for both wheat and grain sorghum. Fertilizer application was assumed to be $3.00 per acre for the application of anhydrous ammonia.

Interest Expense (10) is assumed to be equal to one-half of the sum of the variable cost items multiplied by the interest rate. A 14% interest rate is used.

Total Variable Cost (A) is the sum of lines 1-10. Costs for rented land are less than the costs of owned land because the landlord is assumed to pay 1/3 of fertilizer, herbicide, and insecticide.

Real Estate Taxes (11) on owned land are $0.50 per $100.00 of land value (Langemeier and Krause, 1984). Land value was calculated using KSU Farm Management Association data for the five counties as described before. Long term assets were divided by total acres owned and averaged for each county. Value was found to be $422.45, which was rounded to $425.00, the land value used in this study.

Interest on Land (12) is calculated using a 6% opportunity cost. One-third of the land is owned and interest is calculated on this portion. The cash payment is determined using a 12% interest rate for land financing.

Share Rent (13) is equal to the yield multiplied by the price multiplied by the landlord's share, in this case, one-third, a typical landlord-tenant arrangement in this region.

Depreciation on Machinery (14) is the total depreciation on machinery used in each system divided by the total acreage. Worksheets used in calculating depreciation, insurance, and interest on machinery are in Appendix M.

Calculation of depreciation requires several assumptions to be made regarding the machinery complement. As was noted in the repair section, existing equipment in the CVWF system is assumed to be one-half of its depreciable life and all other equipment was assumed to be purchased new. Depreciable life was assumed to be 10 years for tractors, 12 years for planting equipment, and 14 years for all other equipment.

The depreciable value for each item of machinery was calculated using the 1986 list price discounted appropriately to determine the purchase price. Tractors were discounted 30% and all other machinery was discounted 20%. These discounts were based on recommendations of implement dealers from whom the list prices were obtained.

The purchase price was then discounted by a ratio of price indices for tractors and implements for the appropriate year (USDA, 1987). This provided the depreciable value. Tractors were discounted using the index for 1981 divided by the 1986 index. Planting equipment used the 1980 index and tillage equipment used the 1979 index. New equipment was not discounted. Salvage value was assumed to be a percentage of the depreciable value (Bauscher and Willett, 1986). Appendix I contains the remaining value percentages and the indices used in these calculations.

Annual depreciation is calculated using the straight line method.

The example below calculates the depreciation for the V-blade used in the CVWF system:

Equation (8) Depreciable Value

= List price x (1-Discount) x Beginning Index/End Index

= $9625 x (1-.20) x 119/184
= $4,979.89

Equation (9) Salvage Value

= Depreciable Value x Remaining Value Percentage

= $4,979.89 x .108
= $537.83

Equation (10) Annual Depreciation

= (Depreciable Value - Salvage Value) / Life

= ($4,979.89 - $537.83) / 14
= $317.29

Annual depreciation for each implement and tractor is summed and divided by total acreage to give the depreciation per acre for each system.

Interest on Machinery (15) is equal to one-half of the depreciable value times the interest rate. The interest rate is assumed to be 14%. The per acre cost is the sum of the value for each item of machinery divided by total acres in each system.

Insurance and Housing (16) is assumed to be 1% of the depreciable value (Bauscher and Willett, 1986).

Total Fixed Cost (B) on owned land is the sum of lines 11, 12, 14, 15, and 16. The value for rented land is lines 13-16. In calculating the ownership costs for the wheat and grain sorghum fallow systems, it is necessary to multiply by a factor of two and in the wheat-sorghum fallow systems by three. This is because the total crop acreage on the farm including fallow land is used in the per acre calculations. The figure derived is correct for continuous systems. However, since it takes two years of land management to produce one full crop on the crop-fallow systems and three years in the wheat-grain sorghum-fallow system, these expenses are multiplied by the appropriate factor to properly allocate expenses on an annual basis.

Total Costs Per Acre (C) are the sum of Total Variable Costs (A) and Total Fixed Costs (B) for owned and rented land.

Returns Per Acre (F) are calculated by multiplying the average yield per acre (D) by the average price (E).

Returns over Variable Costs (Ave) are determined by subtracting a weighted average of Total Variable Costs (owned) and Total Variable Costs (rented).

Returns over Total Costs (Owned and Rented Land) (H and I) are equal to Returns Per Acre minus the appropriate Total Costs Per Acre line (C).

Annual Net Returns Per Acre (Ave) (J) is the weighted average of lines H and I, Returns over Total Costs. Owned land accounts for one-third of the cropland in the system, rented land accounts for two-thirds, and each is weighted accordingly.

Net Returns to Management (K) is determined by multiplying Annual Net Returns Per Acre (J) by total annual crop acres. In the continuous systems, there are 1100 crop acres; in the crop-fallow systems, there are 550 acres; and in the wheat-sorghum-fallow system the figure is 366.7 acres. Net returns to management reflect net returns after the deduction of all labor costs, interest expenses, and a return to owned land. Returns must be compared on a total farm basis to reflect the differences in crop and fallow acreage.

Cash costs are included in the budgets. Cash costs per acre are the same as total costs per acre except in the case of labor, interest on variable costs, interest on land, machinery depreciation and interest. Labor is assumed supplied by the operator, unless more than one operation is occurring simultaneously. Cash labor costs are then incurred when labor is hired. The wage rate is $6.00 per hour.

Differences between cash and total interest costs differ because cash costs are incurred only when money is borrowed. However, there is an opportunity cost incurred when money which is owned by the operator is invested in land, machinery, or operating expenses. This opportunity cost represents the value of the best alternative which the farmer could invest in. The cash expense represents the actual interest paid by the operator to a creditor.

Annual depreciation on machinery is a non-cash expense. Machinery deteriorates with use and age. Eventually it will need to be replaced. An annual charge must be made for this deterioration and this is the reason for calculating depreciation and including it as a cost.

CHAPTER FIVE

ANALYSIS AND RESULTS

Net return to management for each crop-tillage system was calculated using enterprise budgets which were developed using 1986 cost of production estimates and eleven year yield and price averages as explained in the previous chapter. Input requirements for all systems are compared as well as yield, price, and income variability. The risk associated with each crop-tillage system is then examined using stochastic dominance techniques.

Annual Field Operations

Annual field operations including acres covered and number and type of operations are summarized in Table 5.1 for each system. All chemicals are assumed to be applied by the operator, while all harvesting operations and fertilizer applications are assumed to be custom hired.

Actual cropping practices from the experiment station for each system were used in compiling this table. In general, no tillage practices were performed on the no-tillage plots. Herbicide applications took the place of tillage operations in these instances. There were generally fewer passes over the field in the no-till systems than in the conventional systems.

Fewer field operations were performed in the continuous systems than in the other cropping systems. However, total acres covered were higher in these systems than in its crop-fallow counterpart due to there being more acres under cultivation each year. The wheat-sorghum-fallow systems had the greatest number of field

TABLE 5.1: ANNUAL FIELD OPERATIONS BY CROPPING SYSTEM

	CROPPING SYSTEM[1]									
	CVWF	NTWF	CVWW	NTWW	CVSS	NTSS	CVSF	NTSF	CVWSF	NTWSF
Annual Acres										
Wheat	550	550	1100	1100	---	---	550	550	366.7	366.7
Sorghum	---	---	---	---	1100	1100	---	---	366.7	366.7
Fallow	550	550	---	---	---	---	550	550	366.7	366.7
CROP ACRES	550	550	1100	1100	1100	1100	550	550	733.3	733.3
OPERATION										
Tillage										
Wheat	6	-	3	-	-	-	-	-	3	-
Sorghum	-	-	-	-	4	-	7	-	4	-
Planting										
Wheat	1	1	1	1	-	-	-	-	1	1
Sorghum	-	-	-	-	1	1	1	1	1	1
SUB-TOTAL	7	1	4	1	5	1	8	1	9	1
Chemical										
Wheat	-	2.5	-	2	-	-	-	-	-	2
Sorghum	-	-	-	-	2	3.5	1	6	1	2.5
Fertilizer[2]										
Wheat	1	1	1	1	-	-	-	-	1	1
Sorghum	-	-	-	-	1	1	1	1	1	1
Harvest[3]										
Wheat	1	1	1	1	-	-	-	-	1	1
Sorghum	-	-	-	-	1	1	1	1	1	1
TOTAL	9	5.5	6	5	9	6.5	11	9	14	10.5
ACRES COVERED	4950	3025	6600	5500	9900	7150	6050	4950	5133	3850

1. CVWF: Conventional Tillage Wheat-Fallow
   NTWF: No-Tillage Wheat-Fallow
   CVWW: Conventional Tillage Continuous Wheat
   NTWW: No-Tillage Continuous Wheat
   CVSS: Conventional Tillage Continuous Sorghum
   NTSS: No-Tillage Continuous Sorghum
   CVSF: Conventional Tillage Sorghum-Fallow
   NTSF: No-Tillage Sorghum-Fallow
   CVWSF: Conventional Tillage Wheat-Sorghum-Fallow
   NTWSF: No-Tillage Wheat-Sorghum-Fallow

2. Fertilizer application custom hired.

3. Harvest operation custom hired.

operations but lower total acreages because there are only 366.7 acres completed in each field operation, compared with 550 acres in crop-fallow systems and 1100 acres in continuous systems.

The conventional system with the highest number of acres covered was the CVSS system with 9900 acres. The NTSS system had the greatest number of acres for a no-till system with 7150. CVWF had the fewest acres for a conventional system with 4950. NTWF had the least for a no-till system with 3025.

Results By Cropping System

Table 5.2 summarizes gross income, selected costs, and net returns for each system. The enterprise budgets developed for each system from which this is summarized are shown in Appendix L. Specific yield and price data which were used are found later in this chapter and in Appendix G.

As shown in Table 5.2, both of the wheat-sorghum-fallow rotations generated positive average net returns with the conventional wheat-sorghum-fallow system (CVWSF) having the highest return of $4,529, followed by the no-till wheat-sorghum-fallow system (NTWSF) with $3,625. The rest of the systems had negative average net returns to management with conventional tillage sorghum-fallow (CVSF) being the third highest, having a return of -$4,989. This was followed in order by the NTWF system with -$6,890; CVWF with -$7,754; NTWW with -$10,062; NTSF with -$11,859; CVWW with -$12,246; NTSS with $19,909; and CVSS with -$21,998.

In addition to having the highest and second highest net returns, the CVWSF and NTWSF systems also generated the fourth and third highest

TABLE 5.2: INCOME, RETURNS, AND SELECTED COSTS BY CROPPING SYSTEM

	CROPPING SYSTEM									
	CVWF	NTWF	CVWW	NTWW	CVSS	NTSS	CVSF	NTSF	CVWSF	NTWSF
GROSS INCOME	50823	57692	75563	80201	94426	94883	70505	66855	82971	89110
Variable Costs										
(Owned)	8379	13350	14274	20007	20437	25830	11001	17706	11387	18188
(Rented)	16174	21602	27005	33411	36778	42071	20710	28128	21636	29932
Total Variable Costs	24553	34952	41279	53417	57215	67901	31711	45834	33023	48119
Fixed Costs										
(Owned)	14333	12360	16672	13101	19503	15363	16129	12765	15753	12614
(Rented)	19691	17270	29858	23745	39706	31529	27653	20115	29666	24751
Total Fixed Costs	34023	29630	46530	36846	59210	46892	43783	32880	45419	37366
TOTAL COSTS	58577	64582	87809	90263	116424	114793	75494	78714	78442	85485
NET RETURN	-7754	-6890	-12246	-10062	-21998	-19909	-4989	-11859	4529	3625
	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
CASH INCOME	6932	2961	8217	2151	6240	-1879	14439	-588	23054	14843
Selected Costs:										
Labor	1821	506	1727	583	2948	1166	2195	688	1753	957
Fuel/Oil	2783	715	3314	1240	4832	1910	3333	1423	2391	911
Chemical	0	18920	1573	22770	12265	35277	2970	28078	1503	23738
Repairs	3080	897	3795	1463	5577	2266	3812	1254	3208	1558
SUBTOTAL	4604	20141	6614	24593	20045	38353	8498	30188	5647	25606
Fertilizer	2448	2448	4895	4895	4895	4895	2448	2448	3263	3263
SUBTOTAL	7051	22588	11509	29488	24940	43248	10945	32636	8910	28869
Depreciation	5902	3130	9075	4169	13046	7348	8316	3702	7854	3494
Interest	7655	5913	12217	8334	17455	12710	10778	7386	24914	21148
TOTAL	23688	32527	36596	43454	61019	65572	33851	44977	44887	55070

gross incomes respectively. NTSS had the highest gross income at $94,883 and CVSS was next with $94,426. These two systems had the highest total costs as well, causing the net returns to be low. The CVSS system had the highest total costs value of $116,424, while NTSS had total costs of $114,793.

In the CVWSF system, relatively higher labor, fuel and oil, repair, depreciation, and interest costs are offset by the increased chemical costs found in the NTWSF system. NTWSF lowered labor costs by $796, fuel and oil costs by $1,480, repair costs by $1,650, machinery depreciation costs by $4,360, and interest costs by $3,776. Higher chemical costs totaling $22,235 more than made up for this however, resulting in an average net return that was $904 below that of the CVWSF system.

This situation was also evident in examining the sorghum-fallow rotations. CVSF had the third highest net return of -$4,989, while NTSF had a net return of -$11,859, a difference of $6,870. CVSF had a gross income that was $3,650 higher than NTSF, but the differences in costs again made a difference. Repairs, depreciation, and interest were lower by $10,564 in the NTSF system, and labor, fuel and oil costs were $3,417 lower. These savings were offset by the NTSF system's higher chemical costs of $25,108.

In each of the other three cropping systems, the no-tillage system had a higher net return than its conventional tillage counterpart. The NTWF system had the fourth highest net return and was followed by the CVWF system. In this case, savings on labor, fuel and oil, repairs, depreciation, and interest were again evident in the no-till system with these costs being $10,081 lower than the CVWF system. Chemical costs were higher, with no chemicals being used on the conventional system and $18,920 worth used on NTWF. In this case, higher gross returns in the NTWF system offset the higher total costs and allowed slightly higher net returns, -$6,890 to -$7,754, a difference of $864.

The continuous wheat systems had the next highest net returns. The NTWW system was sixth highest with a return of -$10,062, followed by CVWW with -$12,246, a difference of $2,184. Chemical costs for the no-till system were $21,197 higher, while labor, fuel and oil, repairs, depreciation, and interest were $14,338 lower. Higher gross returns again made a difference with NTWW having a gross income that was $4,638 higher than that of CVWW.

The lowest net returns were seen in the continuous sorghum systems. These systems had the highest gross returns but also had the highest costs. Net returns in the NTSS system were higher by $2,089. Higher chemical costs were again evident, the difference being $23,012. Other costs were lower by $20,023.

Cash incomes are also noted in Table 5.2. The highest cash income was generated by the CVWSF system with $23,054 followed by the NTWSF system with $14,843. All of the systems showed a positive net cash income except the NTSF and NTSS systems. As explained in the previous chapter, cash costs are incurred only when there is a cash outflow. Some costs, such as depreciation, are non-cash expenses, but must be included in whole farm analysis.

One cash expense that is incurred by most systems is the cost of hired labor. It is assumed that labor is supplied by the operator unless there is more than one field operation occurring simultaneously or that more than one implement is being used to perform an operation. Table 5.3 shows the amount of labor hired annually in each system. The conventional systems are consistently higher than the no-tillage systems, with the CVSS system requiring the most labor hired. Two systems, NTWF and NTWW, do not hire any labor.

Table 5.3: Annual Hired Labor

System	Labor Hired (Hours)
CVWF	114.6
NTWF	0.0
CVWW	121.0
NTWW	0.0
CVSS	220.0
NTSS	89.8
CVSF	119.2
NTSF	12.8
CVWSF	63.0
NTWSF	16.5

Summarized in Figure 5.1 are variable costs (VC), fixed costs (FC), total costs (TC), gross income (GROSS), and net returns to management (NET). Figure 5.2 includes the selected costs of labor, fuel and oil, chemicals including herbicides and insecticides, fertilizer, and repairs for each system. Total costs, fixed costs, depreciation and interest are shown in Figure 5.3.

Variable costs are higher on the no-tillage systems than the conventional systems (Table 5.2). This is due primarily to the higher chemical costs, especially herbicide costs, associated with these systems. Fertilizer costs were the same in each separate cropping system and differed between systems due to the number of crop acres.

FIGURE 5.1: COSTS AND RETURNS

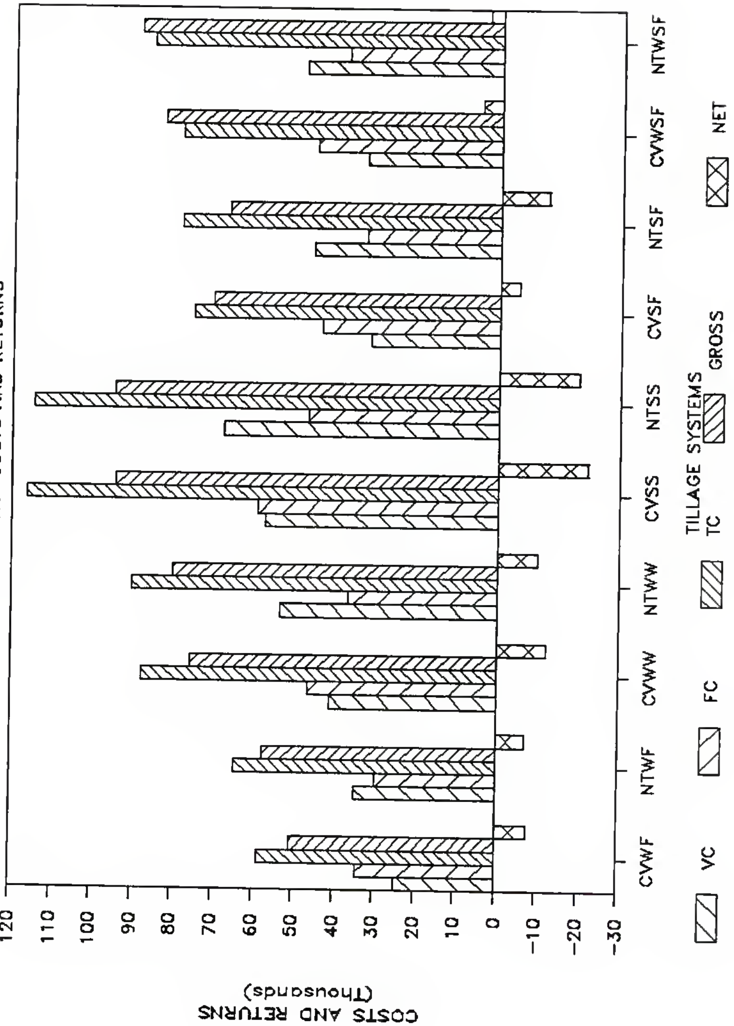


FIGURE 5.2: SELECTED VARIABLE COSTS

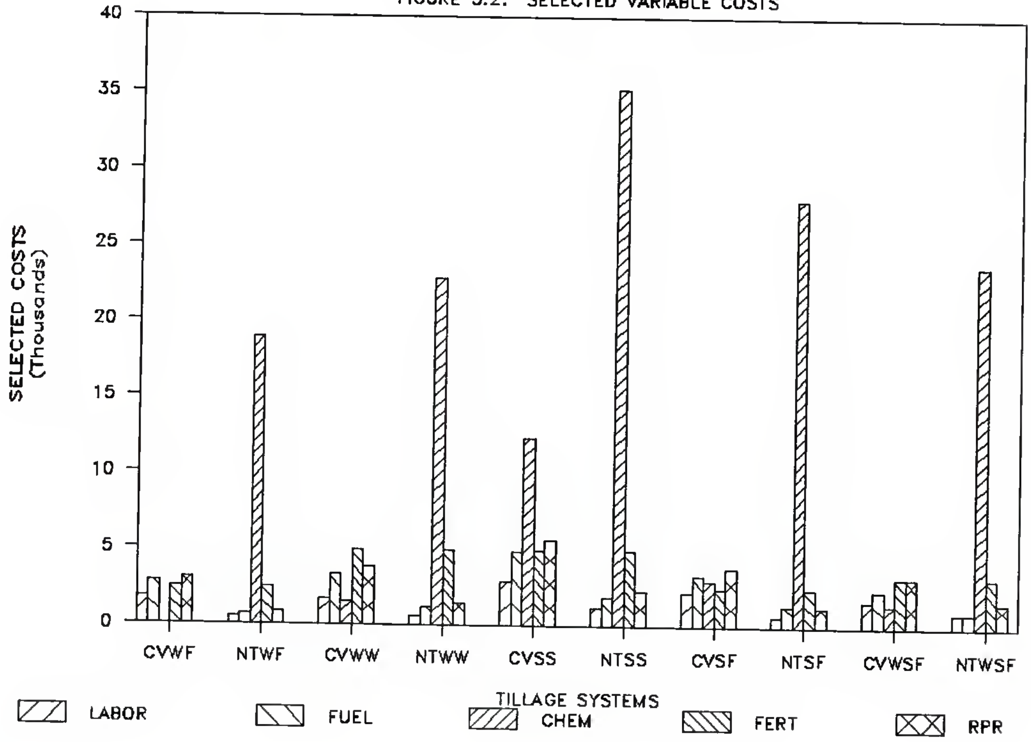
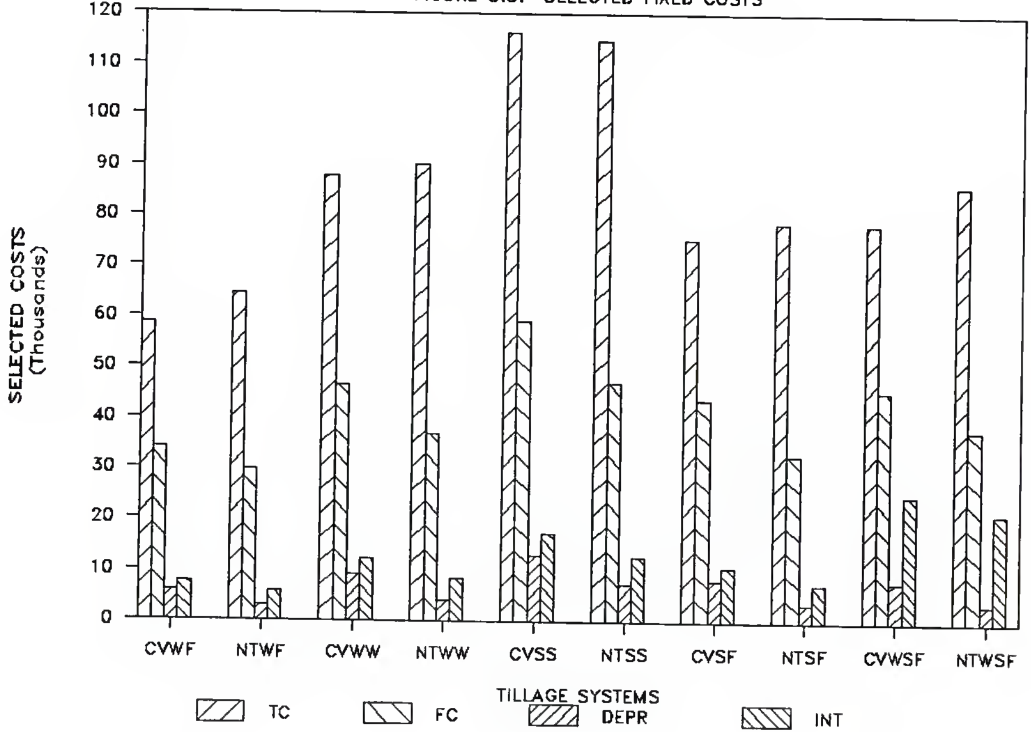


FIGURE 5.3: SELECTED FIXED COSTS



Labor, fuel and oil, and repair costs were consistently lower on the no-till systems because of fewer field operations requiring less machinery and time in the field.

Conventional systems had higher fixed costs. Fixed costs include land and machinery costs for owned land and share rent and machinery costs for rented land. Land costs do not vary with tillage system, and share rent varies with gross returns. Therefore, most of the differences in fixed costs are due to depreciation, interest, insurance and housing costs of the machinery complement. Because of the higher tillage requirements in the conventional systems, these costs are higher than in the no-till systems.

Total costs were not consistent, but were generally higher in the no-till systems. With one exception, the sorghum-fallow system, higher gross returns, indicative of higher yields, were evident in the no-till systems. Of the five cropping systems, net returns for the no-till systems were higher in three and lower in two.

RISK ANALYSIS

In analyzing business risk in agriculture, it is necessary to examine two primary sources of risk: price uncertainty and yield uncertainty. Variability in prices is due to external factors beyond the control of the individual farmer, including supply and demand factors of a particular commodity.

Fluctuations in yield are also due in part to factors not under the control of the operator, such as weather or insect and disease problems as well as management practices used by the operator. Soil moisture, a production factor which is affected by both weather and management practices, was analyzed for each system using Duncan's multiple range test to determine if there were statistical differences in soil moisture between the systems, which might affect yields. Price and yield are the factors influencing annual net returns, which is of concern to the farm operator.

In examining each crop-tillage system for risk, the yield, price, and net return variability of each system is calculated and compared. Statistical measures of standard deviation and coefficient of variation are used in this analysis. Standard deviation is a measure which expresses the variation occurring in a given distribution. This is difficult to use when the distributions have different expected values making the coefficient of variation (CV) useful. CV is equivalent to the standard deviation divided by the mean of the distribution multiplied by 100, and measures variability relative to the mean. The lowest positive coefficient of variation indicates the lowest variability relative to its expected value or simply, the lowest risk relative to the mean.

Variability Analysis

The results of the variability analysis are summarized in Table 5.4. Average wheat yields ranged from 21.7 bushels per acre on the CVWW system to 33.1 bushels per acre on the NTWF system. The range in grain sorghum yields was a low of 41.3 bushels per acre on the CVSS system to a high of 69.6 bushels per acre on the NTWSF system.

Wheat yields had a generally lower coefficient of variation than sorghum indicating lower variability. Yields were lower as well, but the wheat price is generally higher per bushel than sorghum. In

TABLE 5.4: YIELD, PRICE, AND NET RETURN VARIABILITY BY CROPPING SYSTEM, 1976-86

	CROPPING SYSTEM									
	CVWF	NTWF	CVWW	NTWW	CVSS	NTSS	CVSF	NTSF	CVWSF	NTWSF
YIELDS (BU/ACRE) [1]										
Wheat	B	A	C	C					B	AB
Mean [3]	29.2	33.1	21.7	23.0	—	—	—	—	30.2	31.0
Std. Dev.	8.8	7.2	7.3	8.7	—	—	—	—	10.0	7.7
C.V.	30.1	21.7	33.9	38.0	—	—	—	—	33.1	24.8
Sorghum					C	C	AB	B	AB	A
Mean [3]	—	—	—	—	41.3	41.5	61.6	58.4	62.8	69.6
Std. Dev.	—	—	—	—	23.1	22.8	29.9	25.0	24.1	28.2
C.V.	—	—	—	—	55.9	55.0	48.4	42.8	38.4	40.4
PRICES [1]										
Wheat										
Mean	$3.17	$3.17	$3.17	$3.17	—	—	—	—	$3.17	$3.17
Std. Dev.	$0.62	$0.62	$0.62	$0.62	—	—	—	—	$0.62	$0.62
C.V.	19.5	19.5	19.5	19.5	—	—	—	—	19.5	19.5
Sorghum										
Mean	—	—	—	—	$2.08	$2.08	$2.08	$2.08	$2.08	$2.08
Std. Dev.	—	—	—	—	$0.43	$0.43	$0.43	$0.43	$0.43	$0.43
C.V.	—	—	—	—	20.5	20.5	20.5	20.5	20.5	20.5
NET RETURNS [2]										
	ABC	ABC	ABC	ABC	C	BC	ABC	ABC	A	AB
Mean [3]	-8479	-7126	-14286	-12043	-19055	-16874	-6483	-12822	4181	2970
Std. Dev.	15044	15461	21537	27372	62753	62107	35521	31027	32251	32045
C.V.	-177.43	-216.97	-150.76	-227.29	-329.33	-368.06	-547.91	-241.98	771.37	1078.96

1 Based on 1976-86 prices and yields.

2 Based on 1976-86 gross returns and 1986 costs.

3 Means with the same letter are not statistically different.

comparing the wheat systems, NTWF had the lowest standard deviation and coefficient of variation as well as the highest yield while NTWW had the highest CV of the wheat systems, indicating the greatest yield variability.

Among the grain sorghum systems, the wheat-sorghum-fallow systems had the lowest coefficients of variation as well as the highest yields. The lowest yield and highest CV were found in the continuous sorghum systems, although the NTSS system had the lowest standard deviation of yield among these systems.

The average wheat price was $3.17, with sorghum having an average price of $2.08 per bushel. Grain sorghum prices had a lower standard deviation, however the coefficient of variation was slightly lower for wheat prices than for sorghum prices showing that slightly less variability existed in wheat prices for the eleven year period relative to the mean.

Net returns were also examined for variability. Only two systems, CVWSF and NTWSF had positive average returns and thus were the only ones with positive coefficients of variation. Analyzing standard deviation, the lowest values were in the wheat-fallow systems. The wheat-sorghum-fallow systems with the higher average returns had the sixth and seventh lowest standard deviations among the systems. Thus, higher returns were achieved with higher risk.

As noted at the bottom of Table 5.4, means with the same letter are not statistically different. Wheat and grain sorghum yields as well as net returns were analyzed with analysis of variance procedures using Duncan's multiple range test with a confidence level, α = .05.

This procedure identifies distributions whose means differ significantly. The letter "A" indicates means which are statistically higher than those with "B" or "C". Likewise, "B" represents higher means than "C". Thus, for wheat, the NTWF system has statistically higher yields than all systems except NTWSF. The wheat yield for the NTWSF system is neither statistically different from NTWF or CVWSF and CVWF since it has "A" and "B".

For the grain sorghum systems, CVSF and CVWSF do not differ from NTSF or NTWSF, though these do differ from each other. In both wheat and grain sorghum, the continuous systems were statistically lower than the other systems.

This procedure was also used in analyzing net returns. CVWSF was superior to CVSS and NTSS and NTWSF differed significantly from CVSS. There were no other distinctions that could be made however, as most of the systems were not significantly different from each other.

Duncan's test was also used to make comparisons of yields between the type of tillage used, conventional or no-till, and to compare yields between the three cropping systems, crop-fallow, continuous, and wheat-sorghum fallow, for wheat and grain sorghum. Tables 5.5 and 5.6 summarize the results of this.

Table 5.5: ANALYSIS OF WHEAT YIELDS

Rotation	Mean	Grouping
Wheat-fallow (WF)	31.12	A
Wheat-sorghum-fallow (WSF)	30.56	A
Continuous wheat (WW)	22.33	B

Table 5.5 (Continued)

Tillage system		
No-tillage (NT)	29.02	A
Conventional tillage (CV)	26.99	B

Table 5.6: ANALYSIS OF GRAIN SORGHUM YIELDS

Rotation	Mean	Grouping
Wheat-sorghum-fallow (WSF)	66.24	A
Sorghum-fallow (SF)	60.03	A
Continuous sorghum (SS)	41.36	B
Tillage system		
No-tillage (NT)	56.52	A
Conventional tillage (CV)	55.24	A

As can be seen from these tables, the yields on the crop-fallow and wheat-sorghum-fallow rotations were significantly higher than the continuous systems though they did not differ significantly from each other. In addition, there was a significant difference in wheat yields between the no-till and conventional till systems with the no-till systems being significantly higher. No such difference was found in the grain sorghum analysis.

One final analysis was made using this procedure, that being the examination of soil moisture in each system. Tables 5.7 and 5.8 contain the results of this analysis. The soil moisture values are from annual data taken just prior to planting each year and are expressed in inches of water in a six foot profile.

The NTWF system had a six-foot profile soil moisture that was significantly higher than the other wheat systems. This system also had significantly higher yields over all systems except NTWSF, as

Table 5.7: SOIL MOISTURE ANALYSIS IN WHEAT SYSTEMS

	Mean	Grouping
System		
NTWF	6.52	A
CVWF	6.08	B
NTWSF	5.99	BC
CVWSF	5.80	C
NTWW	5.04	D
CVWW	4.78	E
Rotation		
Wheat-fallow	6.30	A
Wheat-sorghum-fallow	5.89	B
Continuous wheat	4.91	C
Tillage system		
No-tillage	5.85	A
Conventional tillage	5.56	B

Table 5.8: SOIL MOISTURE ANALYSIS IN SORGHUM SYSTEM

	Mean	Grouping
System		
NTWSF	6.42	A
NTSF	6.17	B
CVSF	6.09	B
CVWSF	6.04	B
NTSS	5.43	C
CVSS	5.23	C
Rotation		
Wheat-sorghum-fallow	6.23	A
Sorghum-fallow	6.13	A
Continuous sorghum	5.33	B
Tillage system		
No-tillage	6.01	A
Conventional tillage	5.79	B

noted in the discussion above. The continuous wheat systems had soil moisture values that were significantly lower than the other systems and the yields for these systems were also lower as seen above. In the middle of the range, the CVWF and NTWSF systems were statistically the same, and NTWSF was not significantly different from the CVWSF system. These three systems had average yields which were not significantly different.

The wheat-fallow rotations had superior soil moisture values compared to the other two rotations. Wheat-sorghum-fallow rotations for wheat were significantly higher than the continuous wheat systems in terms of soil moisture.

In comparing tillage systems, no-till systems had significantly higher values than the conventional systems in terms of soil moisture. This followed the results for yields, where no-till yields were also significantly higher.

Soil moisture analysis on grain sorghum plots showed that NTWSF had significantly higher values than the other systems. NTSF, CVSF, and CVWSF were not statistically different from each other and the two continuous sorghum systems were statistically lower than any of the others. This compared closely with the results of the yield analysis.

The wheat-sorghum-fallow and sorghum-fallow rotations were both significantly higher in soil moisture than the continuous systems, and the no-tillage systems were higher than the conventional systems. These were the same as the yield analysis with the exception that there was no statistical difference in no-till and conventional tillage yields.

A simple regression analysis was used to determine if there was indeed a positive correlation between yield and soil moisture. Regression analysis can be used to determine if a functional relationship exists between different factors, and if it does, to what degree it exists. A strong positive correlation between yield and soil moisture may indicate that soil moisture may influence yields.

Analyzing wheat systems using a regression with soil moisture as the independent variable and yield as the dependent variable provided an R^2 value of 0.946. The regression equation was $Y = -10.5 + 6.8(X)$, where Y is yield in bushels and X is soil moisture in inches. Similar analysis of grain sorghum systems showed $R^2 = 0.939$. The regression equation here was: $Y = -89.8 + 24.7(X)$ with the variables being the same as above.

The R^2 measures the degree to which the variables are correlated. The closer the R^2 value is to 1.0, the better the correlation. Since the values here are quite close to 1.0 and there are only two variables involved, the correlation between the two can be considered to be quite close. These values are positive, indicating a positive correlation between yield and soil moisture.

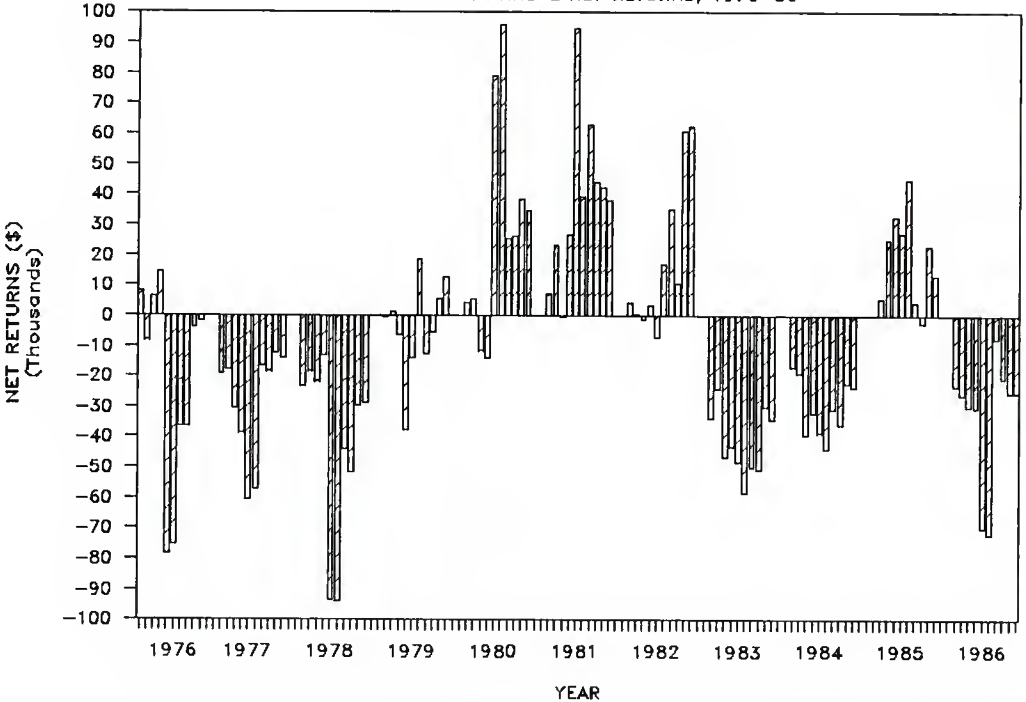
Further analysis of net returns is summarized in Table 5.9, which shows annual net returns for each cropping system. Gross returns were calculated for each year using the yield and price for that year. Net returns were then derived by subtracting 1986 costs. Figure 5.4 graphically shows these values for each year.

As noted above, only two systems had positive average net returns. Those were the wheat-sorghum-fallow systems. They also had positive

TABLE 5.9: ANNUAL NET RETURNS BY CROPPING SYSTEM

YEAR	CROPPING SYSTEM									
	CVWF	NTWF	CVWW	NTWW	CVSS	NTSS	CVSF	NTSF	CVWSF	NTWSF
1976	8181	-8237	6188	14317	-78438	-75303	-36332	-36505	-4027	-1653
1977	-18994	-17667	-30689	-38408	-60322	-57338	-16668	-18203	-12170	-14073
1978	-23476	-18039	-21761	-13052	-93638	-94107	-44127	-51606	-29518	-29041
1979	-313	1256	-6510	-37839	-13936	18490	-12826	-5512	5336	12625
1980	4187	5324	-11575	-13947	78919	96028	25271	26259	38425	34773
1981	7331	23111	-398	26552	94609	39326	63090	44074	42223	38189
1982	4095	174	-1119	3177	-7250	16033	34966	10612	60795	62639
1983	-33902	-24312	-46411	-43301	-48116	-58331	-49859	-50927	-30097	-34492
1984	-17044	-19229	-39520	-32251	-38668	-44025	-31065	-36147	-22449	-23783
1985	59	5473	24908	32587	26907	44660	4073	-2424	22830	12945
1986	-23397	-26245	-30262	-30307	-69673	-71850	-7838	-20663	-25360	-25459
SUM	-93273	-78391	-157150	-132472	-209607	-185617	-71315	-141041	45989	32672
MEAN RETURN	-8479	-7126	-14286	-12043	-19055	-16874	-6483	-12822	4181	2970
STD. DEVIATION	15044	15461	21537	27372	62753	62107	35521	31027	32252	32045
C.V.	-177.42	-216.95	-150.75	-227.29	-329.32	-368.06	-547.90	-241.98	771.43	1078.89
YEARS NEGATIVE	6	6	9	7	8	6	7	8	6	6
TOTAL NEGATIVE	-117127	-113729	-188246	-209106	-410042	-400955	-198714	-221986	-123621	-128500
MINIMUM	-33902	-26245	-46411	-43301	-93638	-94107	-49859	-51606	-30097	-34492
MAXIMUM	8181	23111	24908	32587	94609	96028	63090	44074	60795	62639

FIGURE 5.4: ANNUAL NET RETURNS, 1976–86



Systems for each year from left to right are: CVWF, NTWF, CVWW, NTWW, CVSS, NTSS, CVSF, NTSF, CVWSF, and NTWSF.

coefficients of variation with the CVWSF having a lower CV indicating a lower amount of risk. The wheat-fallow systems had the lowest standard deviations.

A few other things should be noted as well. Five systems, CVWF, NTWF, NTSS, CVWSF, and NTWSF each had the fewest years of negative returns with each having six of the eleven years negative. NTWF had the lowest total amount of losses at $113,729, followed by CVWF with $117,127. The CVSS system had a total of eight years negative returns with the highest loss total of $410,042. CVWW had a total of nine years of negative returns, the most of any system. The highest return in a single year was found in the NTSS system which had one year which returned $96,028. This system also had the largest loss in a single year of $94,107. The smallest minimum value was in the NTWF system which had a low of -$26,245. The smallest maximum value for a system was $8,181 in the CVWF system.

Table 5.10 summarizes selected characteristics of the analysis. Each system is ranked in relative order with 1 being best and 10 being worst for gross income, total variable costs, total fixed costs, total costs, average net returns to management, standard deviation and coefficient of variation of net returns, fewest negative years, least total negative, annual maximum gains and minimum losses, yield mean, standard deviation, and coefficient of variation, and soil moisture mean.

A broader examination of the analysis at this point shows that differences seem to be primarily between cropping systems and not as much between tillage systems. The continuous cropping systems had

Table 5.10: Summary of Analysis[1]

Criteria[2]	System									
	CVWF	NTWF	CVWW	NTWW	CVSS	NTSS	CVSF	NTSF	CVWSF	NTWSF
Gross Income	10	9	6	5	2	1	7	8	4	3
TVC (Least)	1	4	5	8	9	10	2	6	3	7
TFC (Least)	3	1	8	4	10	9	6	2	7	5
TC (Least)	1	2	7	8	10	9	3	5	4	6
Net Returns	5	4	8	6	10	9	3	7	1	2
Std. Dev.	1	2	3	4	10	9	8	5	7	6
Fewest neg. years	1	1	6	6	9	1	6	9	1	1
Least total negative	2	1	5	7	10	9	6	8	3	4
Max. annual income	10	9	8	7	2	1	3	6	5	4
Min. annual loss	3	1	6	5	10	9	7	8	2	4
Yield[3]										
Mean										
Wheat	4	1	6	5	-	-	-	-	3	2
Sorghum	-	-	-	-	F	E	C	D	B	A
Std. Dev.										
Wheat	5	1	2	4	-	-	-	-	6	3
Sorghum	-	-	-	-	B	A	F	D	C	E
CV										
Wheat	3	1	5	6	-	-	-	-	4	2
Sorghum	-	-	-	-	F	E	D	C	A	B
Soil moist.[2]										
Wheat	2	1	6	5	-	-	-	-	4	3
Sorghum	-	-	-	-	F	E	C	B	D	A

[1] 1 is best; 10 is worst

[2] TVC = Total Variable Costs
TFC = Total Fixed Costs
TC = Total Costs
CV = Coefficient of Variation

[3] Numerals denote rankings for wheat systems; letters denote rankings for sorghum systems.

consistently lower yields, lower net returns, and generally higher variability of yields and returns. The wheat-sorghum-fallow systems had the highest net returns, indeed, the only positive net returns.

These systems also had the highest grain sorghum yield and the second and third highest wheat yields. Higher soil moistures were also evident in these systems, possibly accounting for the higher yields.

The wheat-fallow systems had yields which were statistically the same as the wheat-sorghum-fallow systems. NTWF had the highest wheat yield. These systems had lower costs compared to other systems and though net returns were negative, they ranked third and fifth in net returns to management. The sorghum-fallow systems had little that actually distinguished them from the others. These systems had yields and soil moisture contents which did not differ from the wheat-sorghum-fallow systems. Higher costs caused lower net returns though these were higher than the continuous sorghum systems.

It is difficult to make distinctions between conventional tillage and no-tillage systems based on this study. Yields in the grain sorghum systems were not significantly different, though soil moisture at planting was. No-tillage wheat systems had statistically higher yields and soil moisture contents. The higher yields lead to higher gross returns and these systems also experience lower costs for labor, fuel, and equipment, but these are largely offset by increased chemical costs. Thus the need for further analysis.

Stochastic Dominance Analysis

Stochastic dominance analysis uses comparisons of cumulative probability distributions to select a set of efficient strategies from the possible alternatives. In this study, the annual net return distributions for each system shown in Table 5.9 are analyzed using first degree stochastic dominance (FSD), second degree stochastic dominance (SSD), and stochastic dominance with respect to a function (SDWRF).

As outlined in Chapter 3, SDWRF is useful because it is more flexible and has greater discriminating power than FSD and SSD and does not require specification of the decision-maker's utility function. SDWRF orders choices for decision-makers by setting upper and lower bounds to define an interval using the Pratt absolute risk aversion function, R(x). As shown previously, $R(x) = -U''(x)/U'(x)$, the ratio of the second and first derivatives of the decision-maker's utility function, U(x). Risk preference intervals using lower and upper bounds, $R_1(x)$ and $R_2(x)$, can then be established.

King and Robison (1981) suggested that most intervals should be established between the range of -0.0001 and 0.001. Seven risk aversion coefficient intervals were set for the SDWRF analysis. These values were arbitrarily assigned within this suggested range. Risk neutral behavior is generally assumed to be exhibited within the range of -0.00001 and 0.00001. Decision-makers with values above this range would exhibit more risk-averse behavior and those below, more risk-preferring behavior.

Results of stochastic dominance analysis are summarized in Table 5.11. No system dominated all others by FSD or SSD. For FSD, the efficient set included CVWF, NTWF, CVSS, NTSS, CVSF, CVWSF, and NTWSF. The continuous wheat systems and the NTSF system were not included. The efficient set in SSD included NTWF, CVWSF, and NTWSF, eliminating the continuous sorghum systems and the CVWF system. Analysis using SDWRF showed that in the most risk-preferring interval used, $R_1(x)$ =

-0.00005 and $R_2(x)$ = -0.00001, three systems were included in the efficient set, CVSS, NTSS, and CVWSF. The CVWSF system was dominant as the intervals became less risk-preferring and moved into the risk neutral and risk averse area. Further analysis showed that more risk-averse decision-makers would prefer the NTWF system.

Table 5.11: Stochastic Dominance Analysis Results[1]

	$R_1(x)$	$R_2(x)$	CVWF	NTWF	CVWW	NTWW	CVSS	NTSS	CVSF	NTSF	CVWSF	NTWSF
FSD	$-\infty$	$+\infty$	X	X			X	X	X		X	X
SSD	0.0	$+\infty$		X							X	X
SDWRF												
	-0.00005	-0.00001[2]					X	X			X	
	-0.00001	0.0 [2]									X	
	-0.00001	0.00001[3]									X	
	0.0	0.00001[4]									X	
	0.00001	0.00005[4]		X							X	
	0.00005	0.0001 [4]		X								
	0.0001	0.001 [4]		X								

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

[2] Interval in range of risk preferring behavior.

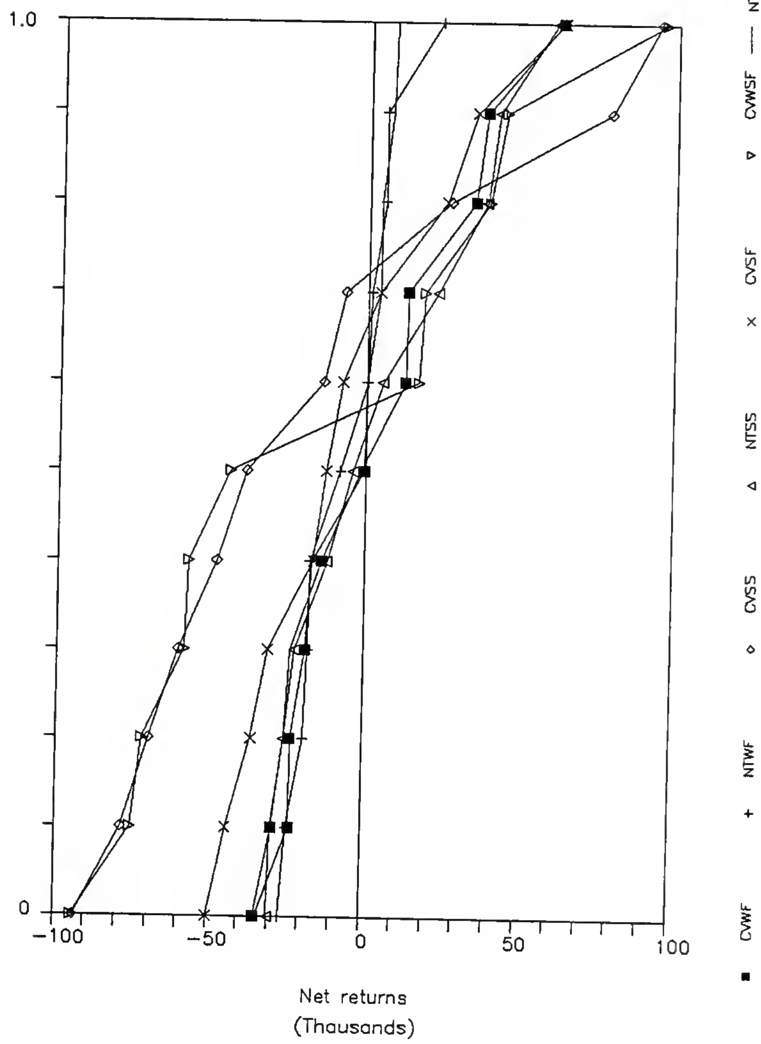
[3] Interval in range of risk-neutral behavior.

[4] Interval in range of risk averse behavior.

The cumulative probability distributions for the seven systems found to be in the efficient set for FSD are shown in Figure 5.5. As detailed in Chapter 3, FSD and SSD can be described graphically. This graph illustrates how close the distributions are.

It can be seen from the graph that these systems are FSD efficient but that CVWF, CVSS, NTSS, and CVSF are not SSD efficient. FSD efficiency requires that the distribution of the dominant function

Figure 5.5: CUMULATIVE PROBABILITY DISTRIBUTIONS



never be above and at least one point be below the distribution with which it is being compared. In this case, no distribution meets these criteria.

For SSD efficiency, the accumulated area under the dominant distribution must never be greater and at some point must be less than the distribuiton which is dominated. It is easiest to see that CVSS and NTSS are dominated under these criteria because the area under these distributions is greater than the area under the dominant distributions. CVWF and CVSF are also dominated, but this is more difficult to see from the graph.

Sensitivity Analysis

Sensitivity analysis is used to estimate the approximate impact of a specified change in one or more variables on the outcome (Boehlje and Eidman, 1984). With sensitivity analysis, it is possible to identify the magnitude of the shift of the dominant distribution necessary to eliminate the dominance and produce an efficient set which would contain the previously dominant system and the specified alternative.

The results of the sensitivity analysis are found in Tables 5.12 and 5.13. Two intervals are used here in sensitivity analysis. Both are in the risk-averse range, since most decision-makers are assumed to be risk averse. In both, the NTWF system is dominant.

The first interval, (0.00005, 0.0001), applies to individuals who are moderately risk averse. If the cumulative probability density distribution for NTWF is lowered by $100.00, it no longer dominates CVWSF in this risk aversion coefficient range. This is equivalent to

Table 5.12: Sensitivity Analysis for the Interval (0.00005,0.0001)

Dominant System		Compared System	Increase In Net Return	Cost Per Acre	Bushels Per Acre
NTWF	<-->	CVWSF	$ 100.00	$ 0.09	.03
NTWF	<-->	NTWSF	1,370.00	1.25	.39
NTWF	<-->	CVWF	1,780.00	1.62	.51
NTWF	<-->	CVWW	11,790.00	10.72	3.38
NTWF	<-->	NTWW	12,690.00	11.53	3.64
NTWF	<-->	CVSF	13,520.00	12.29	3.88
NTWF	<-->	NTSF	17,210.00	15.65	4.94
NTWF	<-->	CVSS	49,260.00	44.78	14.13
NTWF	<-->	NTSS	49,520.00	45.02	14.20
Variation Due to Wheat yields			$11,437.00	$10.40	3.28

Table 5.13: Sensitivity Analysis for the Interval (0.0001,0.001)

Dominant System		Compared System	Increase In Net Return	Cost Per Acre	Bushels Per Acre
NTWF	<-->	CVWF	$ 3,010.00	$ 2.74	.86
NTWF	<-->	CVWSF	3,080.00	2.80	.88
NTWF	<-->	NTWSF	4,730.00	4.30	1.36
NTWF	<-->	CVWW	14,700.00	13.36	4.22
NTWF	<-->	NTWW	15,010.00	13.65	4.30
NTWF	<-->	CVSF	18,080.00	16.44	5.18
NTWF	<-->	NTSF	21,660.00	19.69	6.21
NTWF	<-->	CVSS	57,730.00	52.48	16.56
NTWF	<-->	NTSS	57,900.00	52.64	16.60
Variation Due to Wheat yields			$11,437.00	$10.40	3.28

$0.09 per acre, or only .03 bushel per acre using the average wheat price. This is an almost negligible amount showing that differences between these systems are quite sensitive to yield variation. Values for each system are shown, indicating the decrease necessary to occur in NTWF in order for it to no longer dominate that system. The last line in each table is the variation due to wheat yield. This was calculated using Fischer's LSD to determine the least significant difference in wheat yields, which was found to be 3.28 bushels. A difference of less than 3.28 bushels is not statistically significant. In both intervals, three systems have yield variations less than the LSD value indicating that the analysis is quite sensitive to yield changes and making it difficult to reach substantial conclusions.

In the most strongly risk averse interval used, (0.0001, 0.001), the cumulative probability distribution for NTWF must be decreased by $3,010.00 in order for it to no longer dominate the CVWF system. This is equivalent to $2.74 per acre, or .86 bushels of wheat per acre. Also very close are the CVWSF and NTWSF systems. The values for CVWSF to become a part of the efficient set are $3,080.00 or $2.80 per acre or .88 bushels per acre. For NTWSF to become a part of the efficient set, the distribution for the NTWF system would need to be reduced by $4,730.00 which is equivalent to $4.30 per acre or 1.36 bushels per acre. Again, other systems are compared as well.

It is a bit surprising to find that a risk averse individual would prefer the NTWF system as determined using SDWRF. The small differences found with sensitivity analysis show that NTWF is not strongly dominant and help account for the reason this occurs. This system had a negative average net return and this is what makes it a bit surprising that a risk averse individual would choose this system. However, several things should be noted. This system had the second lowest standard deviation of returns, the lowest total losses, and the smallest annual minimum return. This system also had the second lowest total costs. The lower risk associated with these factors makes this system viable when risk is considered.

CHAPTER SIX

SUMMARY AND CONCLUSIONS

SUMMARY

Interest in conservation tillage has arisen in recent decades due to the potential for reducing soil erosion as well as economic factors such as the potential to reduce energy and labor costs. One type of conservation tillage practice is no-tillage, which replaces tillage with chemical weed control and leaves the surface undisturbed except during planting, when a slot is opened and the seed is dropped into the soil.

Ten conventional and no-tillage wheat and grain sorghum rotations in West-Central, Kansas are evaluated in this study, with the analysis including yield, price, and net return variability, as well as analysis of the risk associated with each system. These ten systems include five conventional tillage and five no-tillage rotations and consist of wheat and grain sorghum in continuous rotations, crop fallow rotations, and in rotation with each other.

Yield data and cropping and tillage practices including variable input levels were obtained from the Fort Hays Branch Experiment Station. These input levels were assumed to be near the economic optimum and that farmers could duplicate the yields on these cropping systems using similar procedures to those being studied at the experiment station.

A representative case farm consisting of 1100 crop acres was established using KSU Farm Management Association data for the region.

According to the farm management data, one-third was assumed to be owned and two-thirds rented.

An equipment complement was selected for each system based on the field operation needs of the system. These operations include tillage, planting, and chemical application on the conventional systems and planting and chemical application on the no-till systems. Harvesting is assumed to be custom hired, so no equipment was selected for harvesting operations.

The conventional wheat-fallow system was used as a benchmark since this is the most common dryland cropping system used in this area. When adopting alternative cropping systems, additional equipment is added to meet the specific requirements of that system. Attention is given to the type of operation, the timely completion of that operation, and approximate speed and field efficiencies for each implement in determining tractor and implement size for each system.

Enterprise budgets were then constructed for each system. Variable costs were determined by calculating the amount of the variable input used and multiplying it by the per unit price. Fixed costs were calculated on a per acre basis for land and machinery costs. Total costs were determined by adding variable and fixed costs. Yield and price data were then used to determine gross returns and the total costs were deducted from gross returns to arrive at a value for net returns to management for each system.

Yields, prices, and net returns were examined for variability using standard deviation, coefficient of variation, and also analysis of variance procedures including Duncan's multiple range test. Soil moisture in each system was examined as well and regression procedures were used to examine the correlation between yield and soil moisture. Stochastic dominance techniques were used to analyze the net returns of each system taking risk into account and sensitivity analysis was used to determine how sensitive the top systems were to yield variations.

RESULTS AND CONCLUSIONS

Only two systems, conventional and no-till wheat-sorghum-fallow, had positive average net returns to management. CVWSF, had the highest return followed by NTWSF. These systems had the fourth and sixth lowest total costs and the fourth and third highest gross returns respectively. The highest gross returns were found in the CVSS system and the lowest costs were in the CVWF and NTWF systems.

The lowest standard deviation of net returns was found in the CVWF system followed closely by NTWF. CVWSF had the lowest positive coefficient of variation, an indication of relatively less risk. NTWF had the least total amount of losses. The least minimum value for a year was also in the NTWF system.

Evaluating yields using analysis of variance procedures showed that wheat yield in the NTWF system were significantly higher than all other wheat systems except NTWSF. CVWSF, NTWSF, and CVSF had sorghum yields which were statistically higher than the other systems. The continuous cropping systems had consistently lower yields than the other systems. Wheat yields on no-till systems were significantly higher than conventional tillage yields. There was not a statistical difference in the sorghum yield between no-till and conventional tillage.

Regression analysis to examine the relationship between yield and soil moisture found that there was a high positive correlation between these two variables, indicating that yields may be affected by soil moisture. The implication of this is that tillage systems which conserve soil moisture, including no-till systems, may be able to produce significantly higher yields and thus higher returns.

Stochastic dominance analysis using first and second degree stochastic dominance determined little that was conclusive. FSD eliminated three of the ten systems and SSD eliminated four more, leaving three systems in the efficient set. Stochastic dominance with respect to a function (SDWRF) was more discriminating, finding that in the risk preferring and risk neutral intervals, the CVWSF system was dominant. In the moderately risk averse range, both CVWSF and NTWF were included in the efficient set. In the more strongly risk averse intervals, NTWF dominated all systems.

Sensitivity analysis revealed that differences between systems were very small and very sensitive to yield variation. In the more risk averse intervals, the yield variation necessary for the NTWF system to no longer dominate was less than the least significant difference in wheat yields for three systems, revealing that the analysis was particularly sensitivity to yield changes.

The small differences between systems help explain why it is that in the more risk averse intervals, the NTWF system was dominant to the other crop-tillage systems. This system had a negative average net return and it is somewhat surprising that a risk averse individual would choose a system with a negative return. However, several things should be noted. This system had the second lowest standard deviation of returns, the lowest total losses, and the smallest annual minimum return. This system also had the second lowest total costs.

The closeness between NTWF and the other systems indicates that it is not highly superior to the others but that the lower risk associated with the factors listed above is enough for it to be included when analyzing these systems with respect to risk.

LIMITATIONS OF THE STUDY

Some of the limitations of this study revolve around the representative case farm and the associated equipment complement which was selected for each system. The case farm relies a great deal on assumptions about farm size and this affects the size and thus the cost of the machinery. Specifically, the lack of data for Ellis County, and the need to use data from nearby counties may have had an effect on the representative farm.

The machinery complement is also affected by the problem of obtaining realistic tillage and planting constraints. These constraints have a direct impact on machinery size and thus on costs, but are difficult to define well. In this study, as noted in Chapter Four, the machinery may be somewhat oversized than may be required in many years. This may have caused excess costs. In addition, determining the proper equipment prices to use was a problem since many retail equipment dealers discount the list price significantly when selling an implement.

This study was based on an agronomic study and included tillage practices and input levels used by the experiment station. These were assumed to be near optimal. It should be realized that the agronomic study was structured to examine the crop yields on different rotations and tillage practices and was not designed specifically for economic analysis, particularly analysis concerning the level of production where marginal revenue equals marginal cost. If the assumption of optimality is incorrect, this study is affected. In addition, the economic analysis did not examine the consequences and value of long-term erosion, which could make no-tillage systems more economical, or the consequences of increased chemical use on the environment and the potential external costs associated with this.

FUTURE RESEARCH NEEDS

The results and limitations of this study point to several additional research needs. Clear definition of the representative case farm and better knowledge of optimal tillage and planting constraints could lead to more realistic equipment complements. Sensitivity analysis of labor rates, fuel prices, interest rate changes, and price changes could produce clearer conclusions. Risk analysis could be expanded to include different crop insurance levels. Examination of the long-term impact of soil erosion should be made and integrated into future studies as well as analysis concerning the externalities associated with high rates of herbicide usage. Further interdisciplinary cooperation could produce research which could be more easily applied to actual farm situations. One final need is to examine whether diversification of stategies is possible and if so, what the results would be using stochastic dominance analysis on a diverse portfolio of activities rather than pure alternatives.

APPENDICES

Appendix A

Appendix A contains the machinery selection worksheets for the conventional and no tillage wheat fallow systems (Schrock, 1976).

The planting operation is the same for both systems and is not limiting. The V-blade operation is the critical operation in the conventional system and is the reason for two tractors. The rodweeder also requires the 130 horsepower tractor. Tables A.1 and A.2 are the worksheets for calculating implement sizes for the CVWF system.

Herbicide application is the limiting operation in the no-till wheat fallow system. This worksheet is shown in table A.3. The worksheet for planting wheat for both systems is shown in table A.4.

Only the most limiting time period is included for each operation.

Table A.1

MACHINERY SELECTION
WORKSHEET
(CVWF)

1. Identify the Critical Job

Description	V-BLADE	
Amount		550 ACRES

2. Estimate the Time Available

Desired Period	JUNE 1-15	
Available Working Days		3.0 DAYS
Hours per Day		10 HOURS
Total Operating Time		30.0 HOURS

3. Size the Machinery to do the Job

Field Capacity Needed:

550 Acres / 30 Hours =	18.33 A/Hour
Speed	5.0 MPH
Field Efficiency	82.5 %

Required Width:

$$\text{Width} = \frac{\text{Field Capacity} * 8.25}{\text{Speed} * \text{Field Efficiency}}$$

$$\text{Width} = \frac{151.25}{4.125} = 36.67 \text{ FEET}$$

4. Estimate Power Requirements

Required Width	36.67 FEET
Power Required (PTO HP/FT)	5.5 HP/FT
Required Tractor Horsepower	201.67 HP

Actual implement size(s): 22 foot V-blade
18 foot V-blade

Actual tractor size(s): 130 HP
110 HP

Table A.2

MACHINERY SELECTION
WORKSHEET
(CVWF)

1. Identify the Critical Job		
Description	RODWEEDER	
Amount		550 ACRES
2. Estimate the Time Available		
Desired Period	SEPTEMBER 10-20	
Available Working Days		4.0 DAYS
Hours per Day		10 HOURS
Total Operating Time		40.0 HOURS
3. Size the Machinery to do the Job		
Field Capacity Needed:		
550 Acres / 40 Hours =		13.75 A/Hour
Speed		5.5 MPH
Field Efficiency		82.5 %
Required Width:		

$$\text{Width} = \frac{\text{Field Capacity} * 8.25}{\text{Speed} * \text{Field Efficiency}}$$

$$\text{Width} = \frac{113.4375}{4.5375} = 25.00 \text{ FEET}$$

4. Estimate Power Requirements		
Required Width		25.00 FEET
Power Required (PTO HP/FT)		4.5 HP/FT
Required Tractor Horsepower		112.50 HP

Actual implement size(s): 25 foot rodweeder

Actual tractor size(s): 130 HP tractor

Table A.3

MACHINERY SELECTION
WORKSHEET
(NTWF)

1. Identify the Critical Job

Description	APPLY HERBICIDE	
Amount		550 ACRES

2. Estimate the Time Available

Desired Period	MAY 1-7	
Available Working Days		3.3 DAYS
Hours per Day		10 HOURS

Total Operating Time		33.0 HOURS

3. Size the Machinery to do the Job

Field Capacity Needed:	
550 Acres / 33 Hours =	16.67 A/Hour
Speed	6.0 MPH
Field Efficiency	60.0 %
Required Width:	

$$\text{Width} = \frac{\text{Field Capacity} * 8.25}{\text{Speed} * \text{Field Efficiency}}$$

$$\text{Width} = \frac{137.50}{3.60} = 38.19 \text{ FEET}$$

4. Estimate Power Requirements

Required Width	38.19 FEET
Power Required (PTO HP/FT)	3.0 HP/FT

Required Tractor Horsepower	114.57 HP

Actual implement size(s): 40 foot boom sprayer

Actual tractor size(s): 130 HP tractor

Table A.4

MACHINERY SELECTION
WORKSHEET
(CVWF-NTWF)

1. Identify the Critical Job

Description	PLANT WHEAT	
Amount		550 ACRES

2. Estimate the Time Available

Desired Period	SEPTEMBER 20 - OCTOBER 5	
Available Working Days	....	5.7 DAYS
Hours per Day	....	10 HOURS
Total Operating Time	....	57.0 HOURS

3. Size the Machinery to do the Job

Field Capacity Needed:

550 Acres / 57 Hours =		9.65 A/Hour
Speed	....	5.0 MPH
Field Efficiency	....	72.5 %

Required Width:

$$\text{Width} = \frac{\text{Field Capacity} * 8.25}{\text{Speed} * \text{Field Efficiency}}$$

$$\text{Width} = \frac{79.605}{3.625} = 21.96 \text{ FEET}$$

4. Estimate Power Requirements

Required Width	....	21.96 FEET
Power Required (PTO HP/FT)	....	4.25 HP/FT
Required Tractor Horsepower	....	93.33 HP

Actual implement size(s): 24 foot hoedrill

Actual tractor size(s): 110 HP tractor

Appendix B

Appendix B contains the machinery selection worksheets for conventional and no tillage continuous wheat systems (Schrock, 1976).

In the conventional system, the disking operation is limiting, requiring two 170 horsepower tractors. These are also used in the V-blade operation and for planting. Tables B.1 and B.2 show the worksheets for these operations.

Planting is limiting in the no tillage system. Table B.4 shows the worksheet for both systems for planting wheat. Table B.3 gives the herbicide application worksheet.

Only the most limiting time period is included for each operation.

Table B.1

MACHINERY SELECTION
WORKSHEET
(CVWW)

1. Identify the Critical Job

Description	V-BLADE	
Amount		1100 ACRES

2. Estimate the Time Available

Desired Period	JULY 10 - 20	
Available Working Days		5.0 DAYS
Hours per Day		10 HOURS
Total Operating Time		50.0 HOURS

3. Size the Machinery to do the Job

Field Capacity Needed:

1100 Acres / 50 Hours =	22.00 A/Hour
Speed	5.0 MPH
Field Efficiency	82.5 %

Required Width:

$$\text{Width} = \frac{\text{Field Capacity} * 8.25}{\text{Speed} * \text{Field Efficiency}}$$

$$\text{Width} = \frac{181.50}{4.125} = 44.00 \text{ FEET}$$

4. Estimate Power Requirements

Required Width	44.00 FEET
Power Required (PTO HP/FT)	5.5 HP/FT
Required Tractor Horsepower	242.00 HP

Actual implement size(s): 22 foot V-blade
22 foot V-blade

Actual tractor size(s): 170 HP tractor
170 HP tractor

Table B.2

MACHINERY SELECTION
WORKSHEET
(CVWW)

1. Identify the Critical Job
   - Description .... DISK
   - Amount .... 1100 ACRES

2. Estimate the Time Available
   - Desired Period .... SEPTEMBER 10-20
   - Available Working Days .... 4.0 DAYS
   - Hours per Day .... 10 HOURS

   Total Operating Time .... 40.0 HOURS

3. Size the Machinery to do the Job
   - Field Capacity Needed:
     - 1100 Acres / 40 Hours = 27.50 A/Hour
     - Speed .... 5.5 MPH
     - Field Efficiency .... 85.0 %
   - Required Width:

$$\text{Width} = \frac{\text{Field Capacity} * 8.25}{\text{Speed} * \text{Field Efficiency}}$$

$$\text{Width} = \frac{226.875}{4.76} = 47.66 \text{ FEET}$$

4. Estimate Power Requirements
   - Required Width .... 47.66 FEET
   - Power Required (PTO HP/FT) .... 7.0 HP/FT

   Required Tractor Horsepower .... 333.64 HP

Actual implement size(s): 24 foot disk
24 foot disk

Actual tractor size(s): 170 HP tractor
170 HP tractor

Table B.3

MACHINERY SELECTION
WORKSHEET
(NTWW)

1. Identify the Critical Job

Description	APPLY HERBICIDE
Amount	1100 ACRES

2. Estimate the Time Available

Desired Period	AUGUST 8-15
Available Working Days	4.7 DAYS
Hours per Day	10 HOURS
Total Operating Time	47.0 HOURS

3. Size the Machinery to do the Job

Field Capacity Needed:

1100 Acres / 47 Hours =	23.40 A/Hour
Speed	6.0 MPH
Field Efficiency	60.0 %

Required Width:

$$\text{Width} = \frac{\text{Field Capacity} * 8.25}{\text{Speed} * \text{Field Efficiency}}$$

$$\text{Width} = \frac{193.085}{3.60} = 53.63 \text{ FEET}$$

4. Estimate Power Requirements

Required Width	53.63 FEET
Power Required (PTO HP/FT)	3.0 HP/FT
Required Tractor Horsepower	160.89 HP

Actual implement size(s): 60 foot boom sprayer

Actual tractor size(s): 170 HP tractor

Table B.4

MACHINERY SELECTION
WORKSHEET
(CVWW-NTWW)

1. Identify the Critical Job
   - Description — PLANT WHEAT
   - Amount .... 1100 ACRES

2. Estimate the Time Available
   - Desired Period — SEPTEMBER 20 - OCTOBER 5
   - Available Working Days .... 5.7 DAYS
   - Hours per Day .... 10 HOURS

   Total Operating Time .... 57.0 HOURS

3. Size the Machinery to do the Job
   - Field Capacity Needed:
     - 1100 Acres / 57 Hours = 19.30 A/Hour
     - Speed .... 5.0 MPH
     - Field Efficiency .... 72.5 %
   - Required Width:

$$\text{Width} = \frac{\text{Field Capacity} * 8.25}{\text{Speed} * \text{Field Efficiency}}$$

$$\text{Width} = \frac{159.210}{3.9875} = 39.93 \text{ FEET}$$

4. Estimate Power Requirements
   - Required Width .... 39.93 FEET
   - Power Required (PTO HP/FT) .... 4.25 HP/FT

   Required Tractor Horsepower .... 169.69 HP

Actual implement size(s): 40 foot hoedrill

Actual tractor size(s): 170 HP tractor

Appendix C

Appendix C contains the machinery selection worksheets for conventional and no tillage continuous sorghum systems (Schrock, 1976).

In the conventional system, three tractors were needed because of time constraints during field preparation and planting when operations are performed concurrently. The large disk (24 ft.) is the reason for the 170 horsepower tractor. This is also used for applying herbicide. The other tractors are used for the other operations. Tables C.1 to C.3 give the worksheets for this system.

The no tillage system requires two 12-row planters like the conventional system and thus the need for the two tractors. Two sprayers are used in herbicide application as well. Table C.4 shows the worksheet for the herbicide application and Table C.5 is the worksheet for planting operations.

Only the most limiting time period is included for each operation.

Table C.1

MACHINERY SELECTION
WORKSHEET
(CVSS)

1. Identify the Critical Job

Description	DISK	
Amount	....	1100 ACRES

2. Estimate the Time Available

Desired Period	MAY 20 - JUNE 5	
Available Working Days	....	5.7 DAYS
Hours per Day	....	10 HOURS
Total Operating Time	....	57.0 HOURS

3. Size the Machinery to do the Job

Field Capacity Needed:

1100 Acres / 57 Hours =		19.30 A/Hour
Speed	....	5.0 MPH
Field Efficiency	....	85.0 %

Required Width:

$$\text{Width} = \frac{\text{Field Capacity} * 8.25}{\text{Speed} * \text{Field Efficiency}}$$

$$\text{Width} = \frac{159.21}{4.25} = 37.46 \text{ FEET}$$

4. Estimate Power Requirements

Required Width	....	37.46 FEET
Power Required (PTO HP/FT)	....	7.0 HP/FT
Required Tractor Horsepower	....	262.23 HP

Actual implement size(s): 24 foot disk
15 foot disk

Actual tractor size(s): 170 HP tractor
110 HP tractor

Table C.2

MACHINERY SELECTION
WORKSHEET
(CVSS)

1. Identify the Critical Job

Description	V-BLADE	
Amount		1100 ACRES

2. Estimate the Time Available

Desired Period	NOVEMBER 5-20	
Available Working Days		6.0 DAYS
Hours per Day		10 HOURS
Total Operating Time		60.0 HOURS

3. Size the Machinery to do the Job

Field Capacity Needed:

1100 Acres / 60 Hours =	18.33 A/Hour
Speed	5.0 MPH
Field Efficiency	82.5 %

Required Width:

$$\text{Width} = \frac{\text{Field Capacity} * 8.25}{\text{Speed} * \text{Field Efficiency}}$$

$$\text{Width} = \frac{151.25}{4.125} = 36.67 \text{ FEET}$$

4. Estimate Power Requirements

Required Width	36.67 FEET
Power Required (PTO HP/FT)	5.5 HP/FT
Required Tractor Horsepower	201.67 HP

Actual implement size(s): 22 foot V-blade
18 foot V-blade

Actual tractor size(s): 130 HP tractor
110 HP tractor

Table C.3

MACHINERY SELECTION
WORKSHEET
(CVSS)

1. Identify the Critical Job

Description		CULTIVATE ROW-CROP
Amount	....	1100 ACRES

2. Estimate the Time Available

Desired Period	JULY 1-15	
Available Working Days	....	7.0 DAYS
Hours per Day	....	10 HOURS
Total Operating Time	....	70.0 HOURS

3. Size the Machinery to do the Job

Field Capacity Needed:

1100 Acres / 70 Hours =		15.71 A/Hour
Speed	....	4.5 MPH
Field Efficiency	....	72.5 %

Required Width:

$$\text{Width} = \frac{\text{Field Capacity} * 8.25}{\text{Speed} * \text{Field Efficiency}}$$

$$\text{Width} = \frac{129.6428}{3.2625} = 39.74 \text{ FEET}$$

4. Estimate Power Requirements

Required Width	....	39.74 FEET
Power Required (PTO HP/FT)	....	4.0 HP/FT
Required Tractor Horsepower	....	158.95 HP

Actual implement size(s): 30 foot cultivator
15 foot cultivator

Actual tractor size(s): 130 HP tractor
110 HP tractor

Table C.4

MACHINERY SELECTION
WORKSHEET
(CVSS-NTSS)

1. Identify the Critical Job
   - Description — APPLY HERBICIDE
   - Amount .... 1100 ACRES

2. Estimate the Time Available
   - Desired Period — MAY 16-23
   - Available Working Days .... 4.2 DAYS
   - Hours per Day .... 10 HOURS

   Total Operating Time .... 42.0 HOURS

3. Size the Machinery to do the Job
   - Field Capacity Needed:
     - 1100 Acres / 42 Hours = 26.19 A/Hour
     - Speed .... 6.0 MPH
     - Field Efficiency .... 60.0 %
   - Required Width:

$$\text{Width} = \frac{\text{Field Capacity} * 8.25}{\text{Speed} * \text{Field Efficiency}}$$

$$\text{Width} = \frac{201.655}{3.60} = 56.02 \text{ FEET}$$

4. Estimate Power Requirements
   - Required Width .... 56.02 FEET
   - Power Required (PTO HP/FT) .... 3.0 HP/FT

   Required Tractor Horsepower .... 168.06 HP

Actual implement size(s): 60 foot boom sprayer (for CVSS)
2 - 30 foot boom sprayers (for NTSS)

Actual tractor size(s): 170 HP tractor (CVSS)
2 -130 HP tractors (NTSS)

Table C.5

MACHINERY SELECTION
WORKSHEET
(CVSS-NTSS)

1. Identify the Critical Job

Description	PLANT SORGHUM
Amount	1100 ACRES

2. Estimate the Time Available

Desired Period	MAY 25 - JUNE 15
Available Working Days	5.4 DAYS
Hours per Day	10 HOURS
Total Operating Time	54.0 HOURS

3. Size the Machinery to do the Job

Field Capacity Needed:

1100 Acres / 54 Hours =	20.37 A/Hour
Speed	4.0 MPH
Field Efficiency	67.5 %

Required Width:

$$\text{Width} = \frac{\text{Field Capacity} * 8.25}{\text{Speed} * \text{Field Efficiency}}$$

$$\text{Width} = \frac{161.205}{2.70} = 59.71 \text{ FEET}$$

4. Estimate Power Requirements

Required Width	59.71 FEET
Power Required (PTO HP/FT)	4.0 HP/FT
Required Tractor Horsepower	238.84 HP

Actual implement size(s): 2 - 30 foot conventional planters (CVSS)
2 - 30 foot Buffalo no-till planters (NTSS)

Actual tractor size(s): 170 HP and 130 HP tractors (CVSS)
2 - 130 HP tractors (NTSS)

Appendix D

Appendix D contains the machinery selection worksheets for conventional and no tillage sorghum fallow systems (Schrock, 1976).

The V-blade operation in the conventional system is limiting. Two tractors, 130 and 110 horsepower, are required. These are both used for disking. The larger tractor is used for the remaining operations. Tables D.1 to D.4 give the worksheets for these operations.

One tractor is needed for the no tillage system and is used for planting and applying herbicide. Table D.5 is the worksheet for planting sorghum and Table D.6 is the worksheet for herbicide application.

Only the most limiting time period is included for each operation.

Table D.1

MACHINERY SELECTION
WORKSHEET
(CVSF)

1.	Identify the Critical Job		
	Description	V-BLADE	
	Amount		550 ACRES
2.	Estimate the Time Available		
	Desired Period	JUNE 1-15	
	Available Working Days		3.0 DAYS
	Hours per Day		10 HOURS
	Total Operating Time		30.0 HOURS
3.	Size the Machinery to do the Job		
	Field Capacity Needed:		
	550 Acres / 30 Hours =		18.33 A/Hour
	Speed		5.0 MPH
	Field Efficiency		82.5 %
	Required Width:		

$$\text{Width} = \frac{\text{Field Capacity} * 8.25}{\text{Speed} * \text{Field Efficiency}}$$

$$\text{Width} = \frac{151.25}{4.125} = 36.67 \text{ FEET}$$

4.	Estimate Power Requirements	
	Required Width	36.67 FEET
	Power Required (PTO HP/FT)	5.5 HP/FT
	Required Tractor Horsepower	201.67 HP

Actual implement size(s): 22 foot V-blade
18 foot V-blade

Actual tractor size(s): 130 HP tractor
110 HP tractor

Table D.2

MACHINERY SELECTION
WORKSHEET
(CVSF)

1.	Identify the Critical Job		
	Description	DISK	
	Amount		550 ACRES
2.	Estimate the Time Available		
	Desired Period	MAY 5-15	
	Available Working Days		4.7 DAYS
	Hours per Day		10 HOURS
	Total Operating Time		47.0 HOURS
3.	Size the Machinery to do the Job		
	Field Capacity Needed:		
	550 Acres / 47 Hours =		11.70 A/Hour
	Speed		5.0 MPH
	Field Efficiency		85.0 %
	Required Width:		

$$\text{Width} = \frac{\text{Field Capacity} * 8.25}{\text{Speed} * \text{Field Efficiency}}$$

$$\text{Width} = \frac{96.542}{4.25} = 22.72 \text{ FEET}$$

4.	Estimate Power Requirements	
	Required Width	22.72 FEET
	Power Required (PTO HP/FT)	7.0 HP/FT
	Required Tractor Horsepower	157.01 HP

Actual implement size(s): 18 foot disk
15 foot disk

Actual tractor size(s): 130 HP tractor
110 HP tractor

Table D.3

MACHINERY SELECTION
WORKSHEET
(CVWF)

1. Identify the Critical Job

Description	RODWEEDER	
Amount		550 ACRES

2. Estimate the Time Available

Desired Period	MAY 15-25	
Available Working Days		4.7 DAYS
Hours per Day		10 HOURS
Total Operating Time		47.0 HOURS

3. Size the Machinery to do the Job

Field Capacity Needed:

550 Acres / 47 Hours =	11.70 A/Hour
Speed	5.5 MPH
Field Efficiency	82.5 %

Required Width:

$$\text{Width} = \frac{\text{Field Capacity} * 8.25}{\text{Speed} * \text{Field Efficiency}}$$

$$\text{Width} = \frac{96.542}{4.5375} = 21.28 \text{ FEET}$$

4. Estimate Power Requirements

Required Width	21.28 FEET
Power Required (PTO HP/FT)	4.5 HP/FT
Required Tractor Horsepower	95.74 HP

Actual implement size(s): 25 foot rodweeder

Actual tractor size(s): 110 HP tractor

Table D.4

MACHINERY SELECTION
WORKSHEET
(CVSF-NTSF)

1. Identify the Critical Job
   - Description .... APPLY HERBICIDE
   - Amount .... 550 ACRES

2. Estimate the Time Available
   - Desired Period .... APRIL 12-18
   - Available Working Days .... 4.0 DAYS
   - Hours per Day .... 10 HOURS
   - Total Operating Time .... 40.0 HOURS

3. Size the Machinery to do the Job
   - Field Capacity Needed:
     - 550 Acres / 40 Hours = 13.75 A/Hour
     - Speed .... 6.0 MPH
     - Field Efficiency .... 60.0 %
   - Required Width:

$$\text{Width} = \frac{\text{Field Capacity} * 8.25}{\text{Speed} * \text{Field Efficiency}}$$

$$\text{Width} = \frac{113.43}{3.60} = 31.51 \text{ FEET}$$

4. Estimate Power Requirements
   - Required Width .... 31.51 FEET
   - Power Required (PTO HP/FT) .... 3.0 HP/FT
   - Required Tractor Horsepower .... 94.53 HP

Actual implement size(s): 40 foot boom sprayer

Actual tractor size(s): 130 HP tractor

Table D.5

MACHINERY SELECTION
WORKSHEET
(CVSF-NTSF)

1. Identify the Critical Job

Description	PLANT SORGHUM	
Amount		550 ACRES

2. Estimate the Time Available

Desired Period	MAY 25 - JUNE 15	
Available Working Days		5.4 DAYS
Hours per Day		10 HOURS
Total Operating Time		54.0 HOURS

3. Size the Machinery to do the Job

Field Capacity Needed:

550 Acres / 54 Hours =	10.19 A/Hour
Speed	4.0 MPH
Field Efficiency	72.5 %

Required Width:

$$\text{Width} = \frac{\text{Field Capacity} * 8.25}{\text{Speed} * \text{Field Efficiency}}$$

$$\text{Width} = \frac{84.027}{2.90} = 28.98 \text{ FEET}$$

4. Estimate Power Requirements

Required Width	28.98 FEET
Power Required (PTO HP/FT)	4.0 HP/FT
Required Tractor Horsepower	115.90 HP

Actual implement size(s): 30 foot conventional planter (CVSF)
30 foot Buffalo no-till planter (NTSF)

Actual tractor size(s): 130 HP tractor

Appendix E

Appendix E contains the machinery selection worksheets for conventional and no tillage wheat-sorghum-fallow rotations (Schrock, 1976).

Two tractors are used in the conventional system. The larger tractor is required for the V-blade operation and is used for the rodweeder. The smaller tractor is used for other operations. Tables E.1 to E.4 contain the tillage worksheets.

The single 110 horsepower tractor is sufficient for all operations in the no-till system. Table E.5 is the worksheet for herbicide application, Table E.6 is the worksheet for planting wheat, and Table E.7 is the worksheet for sorghum planting.

Only the most limiting time period for each operation is included.

Table E.1

MACHINERY SELECTION
WORKSHEET
(CVWSF)

1. Identify the Critical Job

Description	V-BLADE	
Amount		366.7 ACRES

2. Estimate the Time Available

Desired Period	JUNE 1-15	
Available Working Days		3.0 DAYS
Hours per Day		10 HOURS
Total Operating Time		30.0 HOURS

3. Size the Machinery to do the Job

Field Capacity Needed:

366.7 Acres / 30 Hours =	12.22 A/Hour
Speed	5.0 MPH
Field Efficiency	82.5 %

Required Width:

$$\text{Width} = \frac{\text{Field Capacity} * 8.25}{\text{Speed} * \text{Field Efficiency}}$$

$$\text{Width} = \frac{104.8425}{4.125} = 25.41 \text{ FEET}$$

4. Estimate Power Requirements

Required Width	25.41 FEET
Power Required (PTO HP/FT)	5.5 HP/FT
Required Tractor Horsepower	139.76 HP

Actual implement size(s): 26 foot V-blade

Actual tractor size(s): 170 HP tractor

Table E.2

MACHINERY SELECTION
WORKSHEET
(CVWSF)

1. Identify the Critical Job		
Description	DISK	
Amount		366.7 ACRES
2. Estimate the Time Available		
Desired Period	MAY 21-30	
Available Working Days		4.7 DAYS
Hours per Day		10 HOURS
Total Operating Time		47.0 HOURS
3. Size the Machinery to do the Job		
Field Capacity Needed:		
366.7 Acres / 47 Hours =		7.80 A/Hour
Speed		5.0 MPH
Field Efficiency		85.0 %
Required Width:		

$$\text{Width} = \frac{\text{Field Capacity} * 8.25}{\text{Speed} * \text{Field Efficiency}}$$

$$\text{Width} = \frac{63.525}{4.25} = 14.95 \text{ FEET}$$

4. Estimate Power Requirements	
Required Width	14.95 FEET
Power Required (PTO HP/FT)	7.0 HP/FT
Required Tractor Horsepower	104.65 HP

Actual implement size(s): 15 foot disk

Actual tractor size(s): 110 HP tractor

Table E.3

MACHINERY SELECTION
WORKSHEET
(CVWSF)

1. Identify the Critical Job

Description		RODWEEDER
Amount	....	366.7 ACRES

2. Estimate the Time Available

Desired Period		AUGUST 25 - SEPTEMBER 5
Available Working Days	....	5.3 DAYS
Hours per Day	....	10 HOURS
Total Operating Time	....	53.0 HOURS

3. Size the Machinery to do the Job

Field Capacity Needed:

366.7 Acres / 53 Hours =		6.92 A/Hour
Speed	....	5.5 MPH
Field Efficiency	....	82.5 %

Required Width:

$$\text{Width} = \frac{\text{Field Capacity} * 8.25}{\text{Speed} * \text{Field Efficiency}}$$

$$\text{Width} = \frac{57.080}{4.537} = 12.58 \text{ FEET}$$

4. Estimate Power Requirements

Required Width	....	12.58 FEET
Power Required (PTO HP/FT)	....	4.5 HP/FT
Required Tractor Horsepower	....	56.61 HP

Actual implement size(s): 25 foot rodweeder

Actual tractor size(s): 110 HP tractor

Table E.4

MACHINERY SELECTION
WORKSHEET
(CVWSF)

1. Identify the Critical Job

Description		CULTIVATE ROW CROP
Amount	....	366.7 ACRES

2. Estimate the Time Available

Desired Period	JULY 1-15	
Available Working Days	....	7.0 DAYS
Hours per Day	....	10 HOURS
Total Operating Time	....	70.0 HOURS

3. Size the Machinery to do the Job

Field Capacity Needed:

366.7 Acres / 70 Hours =		5.24 A/Hour
Speed	....	4.5 MPH
Field Efficiency	....	72.5 %

Required Width:

$$\text{Width} = \frac{\text{Field Capacity} * 8.25}{\text{Speed} * \text{Field Efficiency}}$$

$$\text{Width} = \frac{43.218}{3.2625} = 13.25 \text{ FEET}$$

4. Estimate Power Requirements

Required Width	....	13.25 FEET
Power Required (PTO HP/FT)	....	4.0 HP/FT
Required Tractor Horsepower	....	52.99 HP

Actual implement size(s): 20 foot cultivator

Actual tractor size(s): 110 HP tractor

Table E.5

MACHINERY SELECTION
WORKSHEET
(CVWSF-NIWSF)

1. Identify the Critical Job		
Description	APPLY HERBICIDE	
Amount		366.7 ACRES
2. Estimate the Time Available		
Desired Period	JULY 8-15	
Available Working Days		3.3 DAYS
Hours per Day		10 HOURS
Total Operating Time		33.0 HOURS
3. Size the Machinery to do the Job		
Field Capacity Needed:		
366.7 Acres / 33 Hours =		11.11 A/Hour
Speed		6.0 MPH
Field Efficiency		60.0 %
Required Width:		

$$\text{Width} = \frac{\text{Field Capacity} * 8.25}{\text{Speed} * \text{Field Efficiency}}$$

$$\text{Width} = \frac{91,675}{3.60} = 25.47 \text{ FEET}$$

4. Estimate Power Requirements	
Required Width	25.47 FEET
Power Required (PTO HP/FT)	3.0 HP/FT
Required Tractor Horsepower	76.41 HP

Actual implement size(s): 30 foot boom sprayer

Actual tractor size(s): 110 HP tractor

Table E.6

MACHINERY SELECTION
WORKSHEET
(CVWSF-NTWSF)

1. Identify the Critical Job		
Description	PLANT WHEAT	
Amount	....	366.7 ACRES
2. Estimate the Time Available		
Desired Period	SEPTEMBER 20 - OCTOBER 5	
Available Working Days	....	5.7 DAYS
Hours per Day	....	10 HOURS
Total Operating Time	....	57.0 HOURS
3. Size the Machinery to do the Job		
Field Capacity Needed:		
366.7 Acres / 57 Hours =		6.43 A/Hour
Speed	....	5.0 MPH
Field Efficiency	....	72.5 %
Required Width:		

$$\text{Width} = \frac{\text{Field Capacity} * 8.25}{\text{Speed} * \text{Field Efficiency}}$$

$$\text{Width} = \frac{53.075}{3.625} = 14.64 \text{ FEET}$$

4. Estimate Power Requirements		
Required Width	....	14.64 FEET
Power Required (PTO HP/FT)	....	4.25 HP/FT
Required Tractor Horsepower	....	62.23 HP

Actual implement size(s): 16 foot hoedrill

Actual tractor size(s): 110 HP tractor

Table E.7

MACHINERY SELECTION
WORKSHEET
(CVWSF-NTWSF)

1. Identify the Critical Job
   Description .... PLANT SORGHUM
   Amount .... 366.7 ACRES

2. Estimate the Time Available
   Desired Period .... MAY 25 - JUNE 15
   Available Working Days .... 5.7 DAYS
   Hours per Day .... 10 HOURS

   Total Operating Time .... 57.0 HOURS

3. Size the Machinery to do the Job
   Field Capacity Needed:
      366.7 Acres / 57 Hours = 6.43 A/Hour
      Speed .... 4.0 MPH
      Field Efficiency .... 72.5 %
   Required Width:

$$\text{Width} = \frac{\text{Field Capacity} * 8.25}{\text{Speed} * \text{Field Efficiency}}$$

$$\text{Width} = \frac{53.075}{2.70} = 19.66 \text{ FEET}$$

4. Estimate Power Requirements
   Required Width .... 19.66 FEET
   Power Required (PTO HP/FT) .... 4.0 HP/FT

   Required Tractor Horsepower .... 78.63 HP

Actual implement size(s): 20 foot conventional planter (CVWSF)
20 foot Buffalo no-till planter (NTWSF)

Actual tractor size(s): 110 HP tractor

Appendix F

Appendix F shows the final machinery complement for each system and the list price of each piece of equipment. List prices for machinery were the average of prices obtained from local dealers for several major brands.

Table F.1: Machinery Complement and List Prices (CVWF)

Implement	Size	Price
V-Blade	22 feet	$ 9,625
V-Blade	18 feet	$ 9,650
Rodweeder	25 feet	$ 7,135
Hoedrill	24 feet	$14,350
2WD Tractor	130 HP	$54,400
2WD Tractor	110 HP	$48,600

Table F.2: Machinery Complement and List Prices (NTWF)

Implement	Size	Price
Hoedrill	24 feet	$14,350
Sprayer	40 feet	$ 3,800
2WD Tractor	130 HP	$54,400

Table F.3: Machinery Complement and List Prices (CVWW)

Implement	Size	Price
V-Blade	22 feet	$ 9,625
V-Blade	22 feet	$ 9,625
Disk	24 feet	$14,950
Disk	24 feet	$14,950
Hoedrill	40 feet	$23,100
2WD Tractor	170 HP	$69,250
2WD Tractor	170 HP	$69,250

Table F.4: Machinery Complement and List Prices (NTWW)

Implement	Size	Price
Hoedrill	40 feet	$23,100
Sprayer	60 feet	$ 4,600
2WD Tractor	170 HP	$69,250

Table F.5: Machinery Complement and List Prices (CVSS)

Implement	Size	Price
Disk	24 feet	$14,950
Disk	15 feet	$ 8,550
V-Blade	22 feet	$ 9,625
V-Blade	18 feet	$ 8,650
Sprayer	60 feet	$ 4,600
Planter (Conventional	30 feet	$26,920
Planter 12 row, 30" rows)	30 feet	$26,920
Cultivator	30 feet	$ 6,060
Cultivator	15 feet	$ 3,300
2WD Tractor	170 HP	$69,250
2WD Tractor	130 HP	$54,400
2WD Tractor	110 HP	$48,600

Table F.6: Machinery Complement and List Prices (NTSS)

Implement	Size	Price
Planter (No-till Buffalo	30 feet	$19,560
Planter 12 row)	30 feet	$19,560
Sprayer	30 feet	$ 3,450
Sprayer	30 feet	$ 3,450
2WD Tractor	130 HP	$54,400
2WD Tractor	130 HP	$54,400

Table F.7: Machinery Complement and List Prices (CVSF)

Implement	Size	Price
V-Blade	22 feet	$ 9,625
V-Blade	18 feet	$ 8,650
Disk	18 feet	$10,900
Disk	15 feet	$ 8,550
Rodweeder	25 feet	$ 7,135
Planter (Conventional 12 row, 30" rows)	30 feet	$26,920
Cultivator	30 feet	$ 6,060
Sprayer	40 feet	$ 3,800
2WD Tractor	130 HP	$54,400
2WD Tractor	110 HP	$48,600

Table F.8: Machinery Complement and List Prices (NTSF)

Implement	Size	Price
Planter (No till, Buffalo 12 row)	30 feet	$19,560
Sprayer	40 feet	$ 3,800
2WD Tractor	130 HP	$54,400

Table F.9: Machinery Complement and List Prices (CVWSF)

Implement	Size	Price
V-Blade	26 feet	$12,500
Disk	15 feet	$ 8,550
Rodweeder	25 feet	$ 7,135
Hoedrill	16 feet	$ 9,560
Planter (Conventional 8 row, 30" rows)	20 feet	$15,430
Cultivator	20 feet	$ 4,600
Sprayer	30 feet	$ 3,450
2WD Tractor	170 HP	$69,250
2WD Tractor	110 HP	$48,600

Table F.10: Machinery Complement and List Prices (NTWSF)

Implement	Size	Price
Planter, (No till, Buffalo 8 row)	20 feet	$14,460
Hoedrill	16 feet	$ 9,560
Sprayer	30 feet	$ 3,450
2WD Tractor	110 HP	$48,600

Appendix G

Appendix G contains input prices, crop prices, and annual crop yields used in the analysis. Input prices were obtained from local suppliers and are an average of several dealers. Crop prices were obtained from the Kansas State Board of Agriculture, Division of Statistics, and are the average annual prices for the central crop reporting district of Kansas. Annual crop yields were obtained from an eleven year yield study conducted at Fort Hays Branch Experiment Station.

Table G.1: Input Prices

Product	Average price	Active Ingredient/Unit
Anhydrous ammonia	$185.00/ton	82%
Atrazine 4L	$8.20/gal.	4 lbs./gal.
Bladex 4L	$18.30/gal.	4 lbs./gal.
Dual	$51.40/gal.	8 lbs./gal.
Glean	$16.40/oz.	75% WDG
Milogard 4L	$12.80/gal.	4 lbs./gal.
Propazine (Princep)	$10.80 gal.	4 lbs./gal.
Roundup	$88.50/gal.	4 lbs./gal.
2,4-D (4 LVE)	$11.40/gal.	4 lbs./gal.

Table G.2: Average Prices, Kansas Central District

Year	Wheat	Grain Sorghum
1976	$2.58	$1.80
1977	2.24	1.73
1978	2.92	1.98
1979	3.75	2.13
1980	3.84	2.80
1981	3.83	2.24
1982	3.63	2.26
1983	3.56	2.67
1984	3.41	2.12
1985	2.91	1.87
1986	2.25	1.28

Table G.3: Annual Crop Yields

WHEAT (Bushels)

	CVWF	NTWF	CVWW	NTWW	CVWSF	NTWSF
1976	46.96	39.56	33.05	36.75	43.20	43.04
1977	32.03	37.91	23.10	20.93	35.70	34.89
1978	21.78	28.85	20.50	23.95	21.59	29.88
1979	28.19	31.82	19.66	12.64	22.44	25.71
1980	29.66	33.00	18.00	18.00	29.66	32.00
1981	31.23	41.53	20.70	27.66	37.70	30.10
1982	31.33	32.33	21.66	23.33	36.00	34.33
1983	12.54	20.46	10.52	11.92	14.01	15.56
1984	22.08	24.07	12.82	15.39	23.30	26.21
1985	36.56	43.64	35.15	38.29	44.91	41.70
1986	28.33	30.81	23.17	24.11	23.19	27.28
MEAN	29.15	33.09	21.67	23.00	30.15	30.97
STD DEV	8.37	6.83	6.99	8.33	9.53	7.34
C.V.	28.73	20.66	32.28	36.24	31.60	23.68

GRAIN SORGHUM (Bushels)

	CVSF	NTSF	CVSS	NTSS	CVSFW	NTSFW
1976	39.40	42.38	19.04	19.76	50.59	64.94
1977	61.66	63.33	29.33	30.00	58.00	67.00
1978	28.66	24.66	10.33	9.33	35.33	33.33
1979	53.36	62.27	43.62	56.73	67.56	80.03
1980	65.33	68.00	63.33	68.33	73.00	73.00
1981	112.36	99.46	85.53	62.40	82.26	98.80
1982	88.74	71.66	43.80	52.80	110.01	123.30
1983	17.35	18.75	23.16	19.10	30.54	31.08
1984	37.97	36.29	33.22	30.19	34.35	36.89
1985	77.21	73.93	69.54	77.34	77.58	78.29
1986	95.88	82.10	33.00	30.24	72.00	79.40
MEAN	61.63	58.44	41.26	41.47	62.84	69.64
STD DEV	28.46	23.84	21.97	21.74	22.99	26.84
C.V.	46.18	40.80	53.26	52.41	36.59	38.54

Appendix H

Appendix H contains the estimated life and repair factors for farm machinery as given by Rotz, (1985). These values are used to calculate repair costs. The values listed for chisel plow were used for the V-blade and the values listed for the field cultivator were used to calculate costs for the rodweeder.

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

Machine	Estimated Life	Repair Factors RC1	RC2
TRACTOR			
2 wheel drive	10000	.01	2.0
TILLAGE			
Disk harrow	2000	.18	1.7
Chisel plow	2000	.38	1.4
Field cultivator	2000	.30	1.4
Row crop cultivator	2000	.22	2.2
PLANTING			
Row crop planter	1200	.54	2.1
Grain drill	1200	.54	2.1
MISCELLANEOUS			
Boom-type sprayer	1500	.41	1.3

Appendix I

Appendix I gives the remaining value percentages of machinery by Bauscher and Willett (1986), used in calculating salvage values, and the index values used in calculating the depreciable values of farm machinery. Table I.1 is the remaining value percentages and Table I.2 is the index values.

Table I.1: Remaining Value of Machinery in Percent (Mohasci, et al.)

Life	Tractor	Other
8	34.9	22.6
9	32.1	20.0
10	29.5	17.7
11	27.2	15.7
12	25.0	13.9
13	23.0	12.3
14	21.2	10.8
15	19.5	9.6

Table I.2: INDICES OF PRICES PAID FOR MACHINERY

YEAR	TRACTORS	OTHER MACHINERY
1978	110	108
1979	122	119
1980	136	132
1981	152	146
1982	165	160
1983	174	171
1984	181	180
1985	178	183
1986	174	184

SOURCE: AGRICULTURAL OUTLOOK, ERS, USDA, APRIL, 1987
1977 = 100

Appendix J

Appendix J contains the calculations of chemical and fertilizer costs for each system.

Table J.1: Chemical and Fertilizer Costs (CVWF)

CHEMICAL APPLIED	DATE	COST/UNIT	AMOUNT	COST/ ACRE	ACRES	TOTAL COST
Nitrogen (NH3)	July 10	$185/ton	40 lbs.	$4.45	550	$2,447.50

FERT. COST/ACRE	HERB. COST/ACRE	INSECT. COST/ACRE
$4.45	----	----

Table J.2: Chemical and Fertilizer Costs (NTWF)

CHEMICAL APPLIED	DATE	COST/UNIT	AMOUNT	COST/ ACRE	ACRES	TOTAL COST
Nitrogen (NH3)	May 5	$185/ton	40 lbs.	$4.45	550	$2,447.50
Glean	May 5	$16.40/oz.	3/8 oz	$6.15	550	$3,382.50
Bladex 4L	May 5	$18.30/gal	2 lbs.	$9.20	550	$5,060.00
Roundup	Aug. 10	$88.50/gal.	16 oz.	$11.06	550	$6,083.00
2,4-D 4 LVE	Aug. 10	$11.40/gal.	1/2 lb.	$1.43	550	$ 786.50
Atrazine 4L (50%)	July 10	$2.05/lb.	1 lb.	$2.05	275	$ 563.75
Roundup (50%)	July 10	$88.50/gal.	16 oz.	$11.06	275	$3,041.50

FERT. COST/ACRE	HERB. COST/ACRE	INS. COST/ACRE
$4.45	$34.40	----

Table J.3: Fertilizer and Chemical Costs (CVWW)

CHEMICAL APPLIED	DATE	COST/UNIT	AMOUNT	COST/ ACRE	ACRES	TOTAL COST
Nitrogen (NH3)	Aug. 15	$185/ton	40 lbs.	$4.45	1100	$4,895.00
2,4-D 4LVE	April 1	$11.40/gal.	1/2 lb.	$1.43	550	$ 786.50

FERT. COST/ACRE	HERB. COST/ACRE	INSECT. COST/ACRE
$4.45	$1.43	---

Table J.4: Fertilizer and Chemical Costs (NTWW)

CHEMICAL APPLIED	DATE	COST/UNIT	AMOUNT	COST/ ACRE	ACRES	TOTAL COST
Roundup	July 10	$88.50/gal.	12 oz.	$8.30	1100	$9,130.00
Roundup	Aug. 10	$88.50/gal.	12 oz.	$8.30	1100	$9,130.00
Nitrogen (NH3)	Aug. 15	$185/ton	40 lbs.	$4.45	1100	$4,895.00
Glean	Aug. 10	$16.40/oz.	1/4 oz.	$4.10	1100	$4,510.00

FERT. COST/ACRE	HERB. COST/ACRE	INSECT. COST/ACRE
$4.45	$20.70	---

Table J.5: Fertilizer and Herbicide Costs (CVSS)

CHEMICAL APPLIED	DATE	COST/UNIT	AMOUNT	COST/ ACRE	ACRES	TOTAL COST
Nitrogen (NH3)	April 15	$185/ton	40 lbs.	$4.45	1100	$4,895.50
Propazine	April 15	$2.70/lb.	2 lbs.	$5.40	1100	$5,940.00
Parathion	August 1	$11.50/lb	1/2 lb.	$5.75	1100	$6,325.00

FERT. COST/ACRE	HERB. COST/ACRE	INSECT. COST/ACRE
$4.45	$5.40	$5.75

Table J.6: Fertilizer and Herbicide Costs (NTSS)

CHEMICAL APPLIED	DATE	COST/UNIT	AMOUNT	COST/ ACRE	ACRES	TOTAL COST
Nitrogen (NH3)	April 15	$185/ton	40 lbs.	$4.45	1100	$4,895.00
Bladex 4L	April 15	$18.30/gal	2 lbs.	$9.20	1100	$10,120.00
Roundup	June 1	$88.50/gal	12 oz.	$8.30	1100	$9,130.00
Dual	June 1	$51.40/gal.	1.5 lbs	$9.64	1100	$10,604.00
Parathion (50%)	August 1	$11.50/lb	1/2 lb.	$5.75	550	$3,162.50
Atrazine 4L	August 1	$2.05/lb.	1 lb.	$2.05	1100	$2,255.00

FERT. COST/ACRE	HERB. COST/ACRE	INSECT. COST/ACRE
$4.45	$29.19	$2.88

Table J.7: Fertilizer and Herbicide Costs (CVSF)

CHEMICAL APPLIED	DATE	COST/UNIT	AMOUNT	COST/ ACRE	ACRES	TOTAL COST
Nitrogen (NH3)	Nov. 15	$185/ton	40 lbs.	$4.45	550	$2,447.50
Propazine	April 15	$2.70/lb.	2 lbs.	$5.40	550	$2,970.00

FERT. COST/ACRE	HERB. COST/ACRE	INSECT. COST/ACRE
$4.45	$5.40	---

Table J.8: Fertilizer and Herbicide Costs (NTSF)

CHEMICAL APPLIED	DATE	COST/UNIT	AMOUNT	COST/ ACRE	ACRES	TOTAL COST
Atrazine 4L	April 15	$2.05/lb.	1 lb.	$2.05	550	$1,127.50
Roundup	June 15	$88.50/gal	12 oz.	$8.30	550	$4,565.00
Roundup	Aug.15	$88.50/gal	12 oz.	$8.30	550	$4,565.00
Atrazine 4L	Nov. 1	$2.05/b.	1 lb.	$2.05	550	$1,127.50
Nitrogen (NH3)	Nov. 15	$185/ton	40 lbs.	$4.45	550	$2,447.50
Bladex 4L	April 15	$18.30/gal	2 lbs.	$9.20	550	$5,060.00
Roundup	May 15	$88.50/gal	12 oz.	$8.30	550	$4,565.00
Dual	May 15	$51.40/gal	2 lbs	$12.85	550	$7,067.50

FERT. COST/ACRE	HERB. COST/ACRE	INSECT. COST/ACRE
$4.45	$51.05	---

Table J.9: Fertilizer and Herbicide Costs (CVWSF)

CHEMICAL APPLIED	DATE	COST/UNIT	AMOUNT	COST/ ACRE	ACRES	TOTAL COST
Nitrogen (NH3) (Wheat)	July 15	$185/ton	40 lbs.	$4.45	366.7	$1,631.68
Atrazine 4L	July 10	$2.05/lb.	2 lbs.	$4.10	366.7	$1,503.35
Nitrogen (NH3) (Sorghum)	Nov. 10	$185/ton	40 lbs.	$4.45	366.7	$1,631.68

FERT. COST/ACRE	HERB. COST/ACRE	INSECT. COST/ACRE
$8.90	$4.10	---

Table J.10: Fertilizer and Herbicide Costs (NTWSF)

CHEMICAL APPLIED	DATE	COST/UNIT	AMOUNT	COST/ ACRE	ACRES	TOTAL COST
Nitrogen (NH3) (Wheat)	May 5	$185/ton	40 lbs.	$4.45	366.7	$1,631.38
Glean	May 5	$16.40/oz.	3/8 oz.	$6.15	366.7	$2,255.00
Bladex 4L	May 5	$18.30/gal	2 lbs.	$9.20	366.7	$3,373.36
Roundup	Aug. 10	$88.50/gal	16 oz.	$11.06	366.7	$4,055.37
2,4-D 4 LVE	Aug. 10	$11.40/gal.	1/2 lb.	$1.43	366.7	$ 524.34
Atrazine 4L (50%)	July 10	$2.05/lb.	1 lb.	$2.05	183.3	$ 375.83
Roundup (50%)	July 10	$88.50/gal	16 oz.	$11.06	183.3	$2,027.63
Bladex 4L	April 15	$18.30/gal	2 lbs.	$9.20	366.7	$3,373.36
Nitrogen (NH3) (Sorghum)	April 15	$185/ton	40 lbs.	$4.45	366.7	$1,631.38
Roundup	May 20	$88.50/gal	12 oz.	$8.30	366.7	$3,043.36
Dual	May 20	$51.40/gal.	2 lbs.	$12.85	366.7	$4,711.71

FERT. COST/ACRE	HERB. COST/ACRE	INSECT. COST/ACRE
$8.90	$64.74	---

Appendix K

Appendix K contains the worksheets used in calculating labor, fuel, oil, and repair costs.

Table K.1 CALCULATION OF LABOR, FUEL, OIL, AND REPAIR COSTS: CVWF

OPERATION	ACRES	FIELD CAPACITY	HOURS	REPAIR $/HOUR	LABOR COST	FUEL COST	OIL COST	REPAIR COST
V-Blade 1	302.5	13.3	22.7	$10.27	$0.25	$0.39	$0.06	$0.42
V-Blade 1	247.5	10.9	22.7	$9.20	$0.25	$0.32	$0.05	$0.38
V-Blade 2	302.5	13.3	22.7	$10.27	$0.25	$0.39	$0.06	$0.42
V-Blade 2	247.5	10.9	22.7	$9.20	$0.25	$0.32	$0.05	$0.38
V-Blade 3	302.5	13.3	22.7	$10.27	$0.25	$0.39	$0.06	$0.42
V-Blade 3	247.5	10.9	22.7	$9.20	$0.25	$0.32	$0.05	$0.38
Rodweeder	550.0	15.2	36.3	$8.92	$0.40	$0.46	$0.07	$0.59
Plant wheat	550.0	14.2	38.6	$14.33	$0.41	$0.39	$0.06	$1.01
V-Blade 4	302.5	13.3	22.7	$10.27	$0.25	$0.39	$0.06	$0.42
V-Blade 4	247.5	10.9	22.7	$9.20	$0.25	$0.32	$0.05	$0.38
V-Blade 5	302.5	13.3	22.7	$10.27	$0.25	$0.39	$0.06	$0.42
V-Blade 5	247.5	10.9	22.7	$9.20	$0.25	$0.32	$0.05	$0.38
TOTAL					$3.31	$4.40	$0.66	$5.60

Table K.2 CALCULATION OF LABOR, FUEL, OIL, AND REPAIR COSTS: NTWF

OPERATION	ACRES	FIELD CAPACITY	HOURS	REPAIR $/HOUR	LABOR COST	FUEL COST	OIL COST	REPAIR COSTS
Apply herbicide 1	550.0	29.1	18.9	$7.20	$0.20	$0.29	$0.04	$0.25
Apply herbicide 2	550.0	29.1	18.9	$7.20	$0.20	$0.29	$0.04	$0.25
Plant wheat	550.0	14.2	38.6	$14.33	$0.41	$0.39	$0.06	$1.01
Apply herbicide 3	275.0	29.1	9.5	$7.20	$0.11	$0.16	$0.02	$0.12
TOTAL					$0.92	$1.13	$0.17	$1.63

Table K.3 CALCULATION OF LABOR, FUEL, OIL, AND REPAIR COSTS: CVWW

OPERATION	ACRES	FIELD CAPACITY	HOURS	REPAIR $/HOUR	LABOR COST	FUEL COST	OIL COST	REPAIR COSTS
V-Blade 1	550.0	13.3	41.3	$11.75	$0.22	$0.36	$0.05	$0.44
V-Blade 1	550.0	13.3	41.3	$11.75	$0.22	$0.36	$0.05	$0.44
V-Blade 2	550.0	13.3	41.3	$11.75	$0.22	$0.36	$0.05	$0.44
V-Blade 2	550.0	13.3	41.3	$11.75	$0.22	$0.36	$0.05	$0.44
Disk 1	550.0	14.6	37.8	$11.29	$0.21	$0.40	$0.06	$0.39
Disk 1	550.0	14.6	37.8	$11.29	$0.21	$0.40	$0.06	$0.39
Plant wheat	1100.0	24.2	45.4	$22.16	$0.25	$0.39	$0.06	$0.91
TOTAL					$1.57	$2.62	$0.39	$3.45

Table K.4 CALCULATION OF LABOR, FUEL, OIL, AND REPAIR COSTS: NTWW

OPERATION	ACRES	FIELD CAPACITY	HOURS	REPAIR $/HOUR	LABOR COST	FUEL COST	OIL COST	
Apply herbicide 1	1100.0	43.6	25.2	$9.05	$0.14	$0.29	$0.04	$0.21
Apply herbicide 2	1100.0	43.6	25.2	$9.05	$0.14	$0.29	$0.04	$0.21
Plant wheat	1100.0	24.2	45.4	$22.16	$0.25	$0.39	$0.06	$0.91
TOTAL					$0.53	$0.98	$0.15	$1.33

Table K.5 CALCULATION OF LABOR, FUEL, OIL, AND REPAIR COSTS: CVSS

OPERATION	ACRES	FIELD CAPACITY	HOURS	REPAIR $/HOUR	LABOR COST	FUEL COST	OIL COST	REPAIR COSTS
Apply herbicide 1	1100.0	43.6	25.2	$7.57	$0.14	$0.29	$0.04	$0.17
Disk 1	628.5	13.8	45.4	$11.29	$0.25	$0.41	$0.06	$0.47
Disk 1	471.5	10.4	45.4	$8.62	$0.25	$0.37	$0.06	$0.36
Disk 2	628.5	13.8	45.4	$11.29	$0.25	$0.41	$0.06	$0.47
Disk 2	471.5	10.4	45.4	$8.62	$0.25	$0.37	$0.06	$0.36
Plant sorghum 1	550.0	14.5	37.8	$24.68	$0.21	$0.24	$0.04	$0.85
Plant sorghum 1	550.0	14.5	37.8	$23.20	$0.21	$0.24	$0.04	$0.80
Cultivate 1	733.3	16.3	44.8	$8.50	$0.24	$0.26	$0.04	$0.35
Cultivate 1	366.7	8.2	44.8	$6.53	$0.24	$0.14	$0.02	$0.27
Apply herbicide 2	1100.0	43.6	25.2	$7.57	$0.14	$0.29	$0.04	$0.17
V-Blade 1	605.0	13.3	45.4	$10.27	$0.25	$0.39	$0.06	$0.42
V-Blade 1	495.0	10.9	45.4	$9.20	$0.25	$0.32	$0.05	$0.38
TOTAL					$2.68	$3.82	$0.57	$5.07

Table K.6 CALCULATION OF LABOR, FUEL, OIL, AND REPAIR COSTS: NTSS

OPERATION	ACRES	FIELD CAPACITY	HOURS	REPAIR $/HOUR	LABOR COST	FUEL COST	OIL COST	REPAIR COST
Apply herbicide 1	733.3	43.6	16.8	$7.57	$0.09	$0.19	$0.03	$0.12
Apply herbicide 1	366.7	21.8	16.8	$7.04	$0.09	$0.10	$0.02	$0.11
Apply herbicide 2	733.3	43.6	16.8	$7.57	$0.09	$0.19	$0.03	$0.12
Apply herbicide 2	366.7	21.8	16.8	$7.04	$0.09	$0.10	$0.02	$0.11
Plant sorghum 1	550.0	14.5	37.8	$18.35	$0.21	$0.24	$0.04	$0.63
Plant sorghum 1	550.0	14.5	37.8	$18.35	$0.21	$0.24	$0.04	$0.63
Apply herbicide 3	366.7	43.6	8.4	$7.57	$0.05	$0.10	$0.02	$0.06
Apply herbicide 3	183.3	21.8	8.4	$7.04	$0.05	$0.05	$0.01	$0.05
Apply herbicide 4	733.3	43.6	16.8	$7.57	$0.09	$0.19	$0.03	$0.12
Apply herbicide 4	366.7	21.8	16.8	$7.04	$0.09	$0.10	$0.02	$0.11
TOTAL					$1.06	$1.51	$0.23	$2.06

Table K.7 CALCULATION OF LABOR, FUEL, OIL, AND REPAIR COSTS: CVSF

OPERATION	ACRES	FIELD CAPACITY	HOURS	REPAIR $/HOUR	LABOR COST	FUEL COST	OIL COST	REPAIR COST
V-Blade 1	302.5	13.3	22.7	$10.27	$0.25	$0.39	$0.06	$0.42
V-Blade 1	247.5	10.9	22.7	$9.20	$0.25	$0.32	$0.05	$0.38
V-Blade 2	302.5	13.3	22.7	$10.27	$0.25	$0.39	$0.06	$0.42
V-Blade 2	247.5	10.9	22.7	$9.20	$0.25	$0.32	$0.05	$0.38
V-Blade 3	302.5	13.3	22.7	$10.27	$0.25	$0.39	$0.06	$0.42
V-Blade 3	247.5	10.9	22.7	$9.20	$0.25	$0.32	$0.05	$0.38
V-Blade 4	302.5	13.3	22.7	$10.27	$0.25	$0.39	$0.06	$0.42
V-Blade 4	247.5	10.9	22.7	$9.20	$0.25	$0.32	$0.05	$0.38
Apply herbicide	550.0	29.1	18.9	$6.62	$0.21	$0.29	$0.04	$0.23
Disk 1	300.0	10.9	27.5	$8.62	$0.30	$0.44	$0.07	$0.43
Disk 1	250.0	9.1	27.5	$7.36	$0.30	$0.37	$0.06	$0.37
Rodweeder	550.0	15.2	36.3	$8.92	$0.40	$0.46	$0.07	$0.59
Plant sorghum	550.0	14.5	37.8	$23.20	$0.41	$0.48	$0.07	$1.59
Cultivate	550.0	16.4	33.5	$8.50	$0.37	$0.38	$0.06	$0.52
TOTAL					$3.99	$5.27	$0.79	$6.93

Table K.8 CALCULATION OF LABOR, FUEL, OIL, AND REPAIR COSTS: NTSF

OPERATION	ACRES	FIELD CAPACITY	HOURS	REPAIR $/HOUR	LABOR COST	FUEL COST	OIL COST	REPAIR COST
Apply herbicide 1	550.0	43.6	12.6	$7.57	$0.14	$0.29	$0.04	$0.17
Apply herbicide 2	550.0	43.6	12.6	$7.57	$0.14	$0.29	$0.04	$0.17
Apply herbicide 3	550.0	43.6	12.6	$7.57	$0.14	$0.29	$0.04	$0.17
Apply herbicide 4	550.0	43.6	12.6	$7.57	$0.14	$0.29	$0.04	$0.17
Apply herbicide 5	550.0	43.6	12.6	$7.57	$0.14	$0.29	$0.04	$0.17
Apply herbicide 6	550.0	43.6	12.6	$7.57	$0.14	$0.29	$0.04	$0.17
Plant sorghum	550.0	14.5	37.8	$18.35	$0.41	$0.48	$0.07	$1.26
TOTAL					$1.25	$2.25	$0.34	$2.28

Table K.9 CALCULATION OF LABOR, FUEL, OIL, AND REPAIR COSTS: CVWSF

OPERATION	ACRES	FIELD CAPACITY	HOURS	REPAIR $/HOUR	LABOR COST	FUEL COST	OIL COST	REPAIR COST
V-Blade 1	366.7	15.8	23.2	$13.19	$0.38	$0.71	$0.11	$0.83
V-Blade 2	366.7	15.8	23.2	$13.19	$0.38	$0.71	$0.11	$0.83
Rodweeder	366.7	15.2	24.1	$10.40	$0.39	$0.46	$0.07	$0.68
Plant wheat	366.7	7.8	47.0	$11.17	$0.77	$0.39	$0.06	$1.43
Apply herbicide	366.7	21.8	16.8	$6.46	$0.27	$0.29	$0.04	$0.30
V-Blade 3	366.7	15.8	23.2	$13.19	$0.38	$0.71	$0.11	$0.83
V-Blade 4	366.7	15.8	23.2	$13.19	$0.38	$0.71	$0.11	$0.83
Disk	366.7	9.1	40.3	$7.36	$0.66	$0.81	$0.12	$0.81
Plant sorghum	366.7	9.7	37.8	$15.04	$0.62	$0.48	$0.07	$1.55
Cultivate	366.7	10.9	33.6	$7.18	$0.55	$0.40	$0.06	$0.66
TOTAL					$4.78	$5.67	$0.85	$8.75

Table K.10 CALCULATION OF LABOR, FUEL, OIL, AND REPAIR COSTS: NTWSF

OPERATION	ACRES	FIELD CAPACITY	HOURS	REPAIR $/HOUR	LABOR COST	FUEL COST	OIL COST	REPAIR COST
Apply herbicide 1	366.7	21.8	16.8	$6.46	$0.27	$0.29	$0.04	$0.30
Apply herbicide 2	366.7	21.8	16.8	$6.46	$0.27	$0.29	$0.04	$0.30
Plant wheat	366.7	7.8	47.0	$11.17	$0.77	$0.39	$0.06	$1.43
Apply herbicide 3	183.3	21.8	8.4	$6.46	$0.14	$0.15	$0.02	$0.15
Apply herbicide 4	366.7	21.8	16.8	$6.46	$0.27	$0.29	$0.04	$0.30
Apply herbicide 5	366.7	21.8	16.8	$6.46	$0.27	$0.29	$0.04	$0.30
Plant sorghum	366.7	9.7	37.8	$14.30	$0.62	$0.48	$0.07	$1.47
TOTAL					$2.61	$2.16	$0.32	$4.25

Appendix L

Appendix L contains the enterprise budgets developed in this study for analysis of the crop-tillage systems.

Table L.1: ENTERPRISE BUDGET

Conventional Wheat-Fallow (CVWF)
Year I: Fallow and Plant Wheat; Year 2: Harvest Wheat

	$/ Bushel	Total	Cash
VARIABLE COSTS PER ACRE			
1. Labor ($6.00/hr. * .552 hours)	0.114	$3.31	$1.25
2. Seed	0.154	$4.50	$4.50
3. Herbicide	0.000	$0.00	$0.00
4. Insecticide	0.000	$0.00	$0.00
5. Fertilizer	0.153	$4.45	$4.45
6. Fuel ($0.95/gallon)	0.151	$4.40	$4.40
7. Oil (.15 * fuel)	0.023	$0.66	$0.66
8. Equipment repair	0.192	$5.60	$5.60
9. Custom Hire	0.672	$19.60	$19.60
10. Interest (1/2 Variable Costs @ 14%)	0.109	$3.19	$1.82
A. TOTAL VARIABLE COSTS (Owned land)	$1.57	$45.70	$42.28
TOTAL VARIABLE COSTS (Rented land)**	$1.52	$44.11	$40.68
FIXED COSTS PER ACRE			
11. Real estate taxes ($.50/$100)	0.146	$4.25	$4.25
12. Interest on land	1.750	$51.00	$34.68
13. Share rent (Returns * .333)	1.056	$30.77	$30.77
14. Depreciation on machinery	0.366	$10.67	$0.00
15. Interest on machinery	0.368	$10.73	$3.57
16. Insurance/Housing	0.052	$1.53	$1.53
B. TOTAL FIXED COSTS (Owned land)	$2.68	$78.18	$44.03
TOTAL FIXED COSTS (Rented land)	$1.84	$53.70	$35.87
C. TOTAL COSTS PER ACRE (Owned land)	$4.25	$123.88	$86.31
TOTAL COSTS PER ACRE (Rented land)	$3.36	$97.81	$76.55
D. YIELD PER ACRE		29.15	
E. PRICE / BUSHEL		$3.17	
F. RETURNS PER ACRE (Row D * Row E)		$92.41	
G. RETURNS OVER VARIABLE COSTS (AVE.)	$1.53	$47.76	$51.19
H. RETURNS OVER TOTAL COSTS (Owned land)	($1.08)	($31.48)	$6.10
I. RETURNS OVER TOTAL COSTS (Rented land)	($0.19)	($5.41)	$15.85
J. ANNUAL NET RETURNS PER ACRE (AVE.)		($14.09)	$12.60
K. NET RETURNS TO MANAGEMENT (Row J * Crop Acres)		($7,749.02)	$6,931.99

** Assumes landlord pays 1/3 of fertilizer, herbicide, insecticide cost on rented land.

Table L.2: ENTERPRISE BUDGET

No-Till Wheat-Fallow (NTWF)
Year 1: Fallow and Plant Wheat; Year 2: Harvest Wheat

	$/ Bushel	Total	Cash
VARIABLE COSTS PER ACRE			
1. Labor ($6.00/hr. * .153 hours)	0.028	$0.92	$0.00
2. Seed	0.136	$4.50	$4.50
3. Herbicide	1.040	$34.40	$34.40
4. Insecticide	0.000	$0.00	$0.00
5. Fertilizer	0.134	$4.45	$4.45
6. Fuel ($0.95/gallon)	0.034	$1.13	$1.13
7. Oil (.15 * fuel)	0.005	$0.17	$0.17
8. Equipment repair	0.048	$1.60	$1.60
9. Custom Hire	0.621	$20.54	$20.54
10. Interest (1/2 Variable Costs @ 14%)	0.154	$5.08	$3.01
A. TOTAL VARIABLE COSTS (Owned land)	$2.20	$72.82	$69.83
TOTAL VARIABLE COSTS (Rented land)**	$1.78	$58.91	$55.92
FIXED COSTS PER ACRE			
11. Real estate taxes ($.50/$100)	0.128	$4.25	$4.25
12. Interest on land	1.541	$51.00	$34.68
13. Share rent (Returns * .333)	1.056	$34.93	$34.93
14. Depreciation on machinery	0.172	$5.69	$0.00
15. Interest on machinery	0.171	$5.67	$1.89
16. Insurance/Housing	0.024	$0.81	$0.81
B. TOTAL FIXED COSTS (Owned land)	$2.04	$67.42	$41.63
TOTAL FIXED COSTS (Rented land)	$1.42	$47.10	$37.63
C. TOTAL COSTS PER ACRE (Owned land)	$4.24	$140.24	$111.46
TOTAL COST PER ACRE (Rented land)	$3.20	$106.01	$93.55
D. YIELD PER ACRE		33.09	
E. PRICE / BUSHEL		$3.17	
F. RETURNS PER ACRE (Row D * Row E)		$104.90	
G. RETURNS OVER VARIABLE COSTS (AVE.)	$1.25	$41.35	$44.34
H. RETURNS OVER TOTAL COSTS (Owned land)	($1.07)	($35.35)	($6.56)
I. RETURNS OVER TOTAL COSTS (Rented land)	($0.03)	($1.12)	$11.35
J. ANNUAL NET RETURNS PER ACRE (AVE.)		($12.52)	$5.38
K. NET RETURNS TO MANAGEMENT (Row J * Crop Acres)		($6,883.91)	$2,961.14

** Assumes landlord pays 1/3 of fertilizer, herbicide, insecticide cost on rented land.

Table L.3: ENTERPRISE BUDGET

Conventional Till Continuous Wheat (CVWW)
Year 1: Harvest, Till and Plant Wheat

	$/ Bushel	Total	Cash
VARIABLE COSTS PER ACRE			
1. Labor ($6.00/hr. * .253 hours)	0.072	$1.57	$0.66
2. Seed	0.208	$4.50	$4.50
3. Herbicide	0.066	$1.43	$1.43
4. Insecticide	0.000	$0.00	$0.00
5. Fertilizer	0.205	$4.45	$4.45
6. Fuel ($0.95/gallon)	0.121	$2.62	$2.62
7. Oil (.15 * fuel)	0.018	$0.39	$0.39
8. Equipment repair	0.159	$3.45	$3.45
9. Custom Hire	0.821	$17.80	$17.80
10. Interest (1/2 Variable Costs @ 14%)	0.125	$2.72	$1.59
A. TOTAL VARIABLE COSTS (Owned land)	$1.80	$38.93	$36.89
TOTAL VARIABLE COSTS (Rented land)**	$1.70	$36.82	$34.79
FIXED COSTS PER ACRE			
11. Real estate taxes ($.50/$100)	0.098	$2.13	$2.13
12. Interest on land	1.177	$25.50	$17.34
13. Share rent (Returns * .333)	1.056	$22.88	$22.88
14. Depreciation on machinery	0.381	$8.25	$0.00
15. Interest on machinery	0.387	$8.39	$2.79
16. Insurance/Housing	0.055	$1.20	$1.20
B. TOTAL FIXED COSTS (Owned land)	$2.10	$45.47	$23.46
TOTAL FIXED COSTS (Rented land)	$1.88	$40.72	$26.87
C. TOTAL COSTS PER ACRE (Owned land)	$3.89	$84.40	$60.36
TOTAL COST PER ACRE (Rented land)	$3.58	$77.54	$61.66
D. YIELD PER ACRE		21.67	
E. PRICE / BUSHEL		$3.17	
F. RETURNS PER ACRE (Row D * Row E)		$68.69	
G. RETURNS OVER VARIABLE COSTS (AVE.)	$1.44	$31.17	$33.21
H. RETURNS OVER TOTAL COSTS (Owned land)	($0.72)	($15.71)	$ 8.34
I. RETURNS OVER TOTAL COSTS (Rented land)	($0.41)	($8.85)	$7.04
J. ANNUAL NET RETURNS PER ACRE (AVE.)		($11.13)	$7.47
K. NET RETURNS TO MANAGEMENT (Row J * Crop Acres)		($12,243.87)	$8,217.48

** Assumes landlord pays 1/3 of fertilizer, herbicide, insecticide on rented land.

Table L.4: ENTERPRISE BUDGET

No Till Continuous Wheat (NTWW)
Year 1: Harvest and Plant Wheat

	$/ Bushel	Total	Cash
VARIABLE COSTS PER ACRE			
1. Labor ($6.00/hr. * .080 hours)	0.023	$0.53	$0.00
2. Seed	0.196	$4.50	$4.50
3. Herbicide	0.900	$20.70	$20.70
4. Insecticide	0.000	$0.00	$0.00
5. Fertilizer	0.193	$4.45	$4.45
6. Fuel ($0.95/gallon)	0.043	$0.98	$0.98
7. Oil (.15 * fuel)	0.006	$0.15	$0.15
8. Equipment repair	0.058	$1.33	$1.33
9. Custom Hire	0.788	$18.12	$18.12
10. Interest (1/2 Variable Costs @ 14%)	0.166	$3.81	$2.26
A. TOTAL VARIABLE COSTS (Owned land)	$2.37	$54.56	$52.49
TOTAL VARIABLE COSTS (Rented land)**	$1.98	$45.56	$43.48
FIXED COSTS PER ACRE			
11. Real estate taxes ($.50/$100)	0.093	$2.13	$2.13
12. Interest on land	1.109	$25.50	$17.34
13. Share rent (Returns * .333)	1.056	$24.28	$24.28
14. Depreciation on machinery	0.165	$3.79	$0.00
15. Interest on machinery	0.164	$3.77	$1.26
16. Insurance/Housing	0.023	$0.54	$0.54
B. TOTAL FIXED COSTS (Owned land)	$1.55	$35.73	$21.27
TOTAL FIXED COSTS (Rented land)	$1.41	$32.38	$26.07
C. TOTAL COSTS PER ACRE (Owned land)	$3.93	$90.29	$73.75
TOTAL COST PER ACRE (Rented land)	$3.39	$77.94	$69.56
D. YIELD PER ACRE		23.00	
E. PRICE / BUSHEL		$3.17	
F. RETURNS PER ACRE (Row D * Row E)		$72.91	
G. RETURNS OVER VARIABLE COSTS (AVE.)	$1.06	$24.35	$26.43
H. RETURNS OVER TOTAL COSTS (Owned land)	($0.76)	($17.38)	$0.84
I. RETURNS OVER TOTAL COSTS (Rented land)	($0.22)	($5.03)	$3.35
J. ANNUAL NET RETURNS PER ACRE (AVE.)		($9.14)	$1.96
K. NET RETURNS TO MANAGEMENT (Row J * Crop Acres)		($10,048.03)	$2,150.74

** Assumes landlord pays 1/3 of fertilizer, herbicide, and insecticide cost on rented land.

Table L.5: ENTERPRISE BUDGET

Conventional Till Continuous Sorghum (CVSS)
Year 1: Till, Plant Sorghum and Harvest

	$/ Bushel	Total	Cash
VARIABLE COSTS PER ACRE			
1. Labor ($6.00/hr. * .572 hours)	0.065	$2.68	$1.20
2. Seed	0.068	$2.80	$2.80
3. Herbicide	0.131	$5.40	$5.40
4. Insecticide	0.139	$5.75	$5.75
5. Fertilizer	0.108	$4.45	$4.45
6. Fuel ($0.95/gallon)	0.093	$3.82	$3.82
7. Oil (.15 * fuel)	0.014	$0.57	$0.57
8. Equipment repair	0.123	$5.07	$5.07
9. Custom Hire	0.516	$21.30	$21.30
10. Interest (1/2 Variable Costs @ 14%)	0.094	$3.89	$2.27
A. TOTAL VARIABLE COSTS (Owned land)	$1.35	$55.74	$52.63
TOTAL VARIABLE COSTS (Rented land)**	$1.22	$50.15	$47.05
FIXED COSTS PER ACRE			
11. Real estate taxes ($.50/$100)	0.052	$2.13	$2.13
12. Interest on land	0.618	$25.50	$17.34
13. Share rent (Returns * .333)	0.693	$28.59	$28.59
14. Depreciation on machinery	0.287	$11.86	$0.00
15. Interest on machinery	0.290	$11.98	$3.99
16. Insurance/Housing	0.042	$1.72	$1.72
B. TOTAL FIXED COSTS (Owned land)	$1.29	$53.19	$25.18
TOTAL FIXED COSTS (Rented land)	$1.31	$54.15	$34.29
C. TOTAL COSTS PER ACRE (Owned land)	$2.64	$108.93	$77.81
TOTAL COST PER ACRE (Rented land)	$2.53	$104.30	$81.34
D. YIELD PER ACRE		41.27	
E. PRICE / BUSHEL		$2.08	(3.71/cwt)
F. RETURNS PER ACRE (Row D * Row E)		$85.84	
G. RETURNS OVER VARIABLE COSTS (AVE.)	$0.82	$33.83	$36.93
H. RETURNS OVER TOTAL COSTS (Owned land)	($0.56)	($23.08)	$8.03
I. RETURNS OVER TOTAL COSTS (Rented land)	($0.45)	($18.46)	$4.50
J. ANNUAL NET RETURNS PER ACRE (AVE.)		($20.00)	$5.67
K. NET RETURNS TO MANAGEMENT (Row J * Crop Acres)		($22.002.46)	$6,240.41

** Assumes landlord pays 1/3 of fertilizer, herbicide, insectide cost on rented land.

Table L.6: ENTERPRISE BUDGET

No Till Continuous Sorghum (NTSS)
Year 1: Plant Sorghum and Harvest

	$/ Bushel	Total	Cash
VARIABLE COSTS PER ACRE			
1. Labor ($6.00/hr. * .172 hours)	0.026	$1.06	$0.49
2. Seed	0.068	$2.80	$2.80
3. Herbicide	0.704	$29.19	$29.19
4. Insecticide	0.069	$2.88	$2.88
5. Fertilizer	0.107	$4.45	$4.45
6. Fuel ($0.95/gallon)	0.036	$1.51	$1.51
7. Oil (.15 * fuel)	0.005	$0.23	$0.23
8. Equipment repair	0.050	$2.06	$2.06
9. Custom Hire	0.515	$21.35	$21.35
10. Interest (1/2 Variable Costs @ 14%)	0.119	$4.91	$2.92
A. TOTAL VARIABLE COSTS (Owned land)	$1.70	$70.44	$67.88
TOTAL VARIABLE COSTS (Rented land)**	$1.38	$57.37	$54.81
FIXED COSTS PER ACRE			
11. Real estate taxes ($.50/$100)	0.051	$2.13	$2.13
12. Interest on land	0.615	$25.50	$17.34
13. Share rent (Returns * .333)	0.693	$28.72	$28.72
14. Depreciation on machinery	0.161	$6.68	$0.00
15. Interest on machinery	0.160	$6.64	$2.21
16. Insurance/Housing	0.023	$0.95	$0.95
B. TOTAL FIXED COSTS (Owned land)	$1.01	$41.90	$22.63
TOTAL FIXED COSTS (Rented land)	$1.06	$42.99	$31.88
C. TOTAL COSTS PER ACRE (Owned land)	$2.71	$112.34	$90.51
TOTAL COST PER ACRE (Rented land)	$2.42	$100.36	$86.69
D. YIELD PER ACRE		41.47	
E. PRICE / BUSHEL		$2.08	(3.71/cwt)
F. RETURNS PER ACRE (Row D * Row E)		$86.26	
G. RETURNS OVER VARIABLE COSTS (AVE.)	$0.59	$24.53	$27.10
H. RETURNS OVER TOTAL COSTS (Owned land)	($0.63)	($26.09)	($4.26)
I. RETURNS OVER TOTAL COSTS (Rented land)	($0.34)	($14.11)	$0.44
J. ANNUAL NET RETURNS PER ACRE (AVE.)		($18.10)	($1.71)
K. NET RETURNS TO MANAGEMENT (Row J * Crop Acres)		($19,907.03)	($1,878.58)

** Assumes landlord pays 1/3 of fertilizer, herbicide, insecticide cost on rented land.

Table L.7: ENTERPRISE BUDGET

Conventional Till Sorghum-Fallow (CVSF)
Year 1: Plant and Harvest Sorghum; Year 2: Fallow

	$/ Bushel	Total	Cash
VARIABLE COSTS PER ACRE			
1. Labor ($6.00/hr. * .847 hours)	0.065	$3.99	$1.30
2. Seed	0.045	$2.80	$2.80
3. Herbicide	0.088	$5.40	$5.40
4. Insecticide	0.000	$0.00	$0.00
5. Fertilizer	0.072	$4.45	$4.45
6. Fuel ($0.95/gallon)	0.086	$5.27	$5.27
7. Oil (.15 * fuel)	0.013	$0.79	$0.79
8. Equipment repair	0.112	$7.93	$7.93
9. Custom Hire	0.425	$26.19	$26.19
10. Interest (1/2 Variable Costs @ 14%)	0.068	$4.19	$2.39
A. TOTAL VARIABLE COSTS (Owned land)	$0.97	$60.01	$55.52
TOTAL VARIABLE COSTS (Rented land)**	$0.92	$56.48	$52.00
FIXED COSTS PER ACRE			
11. Real estate taxes ($.50/$100)	0.069	$4.25	$4.25
12. Interest on land	0.828	$51.00	$34.68
13. Share rent (Returns * .333)	0.693	$42.69	$42.69
14. Depreciation on machinery	0.245	$15.12	$0.00
15. Interest on machinery	0.250	$15.41	$5.13
16. Insurance/Housing	0.036	$2.20	$2.20
B. TOTAL FIXED COSTS (Owned land)	$1.43	$87.98	$46.26
TOTAL FIXED COSTS (Rented land)	$1.22	$75.43	$50.02
C. TOTAL COSTS PER ACRE (Owned land)	$2.40	$147.99	$101.78
TOTAL COST PER ACRE (Rented land)	$2.14	$131.90	$102.01
D. YIELD PER ACRE		61.63	
E. PRICE / BUSHEL		$2.08	(3.71/cwt)
F. RETURNS PER ACRE (Row D * Row E)		$128.19	
G. RETURNS OVER VARIABLE COSTS (AVE.)	$1.14	$70.53	$75.02
H. RETURNS OVER TOTAL COSTS (Owned land)	($0.32)	($19.80)	$26.41
I. RETURNS OVER TOTAL COSTS (Rented land)	($0.06)	($3.71)	$26.18
J. ANNUAL NET RETURNS PER ACRE (AVE.)		($9.07)	$26.25
K. NET RETURNS TO MANAGEMENT (Row J * Crop Acres)		($4,986.35)	$14,438.94

** Assumes landlord pays 1/3 of fertilizer, herbicide, insecticide cost on rented land.

Table L.8: ENTERPRISE BUDGET

No Till Sorghum-Fallow (NTSF)
Year 1: Plant and Harvest Sorghum; Year 2: Fallow

	$/ Bushel	Total	Cash
VARIABLE COSTS PER ACRE			
1. Labor ($6.00/hr. * .345 hours)	0.021	$1.25	$0.14
2. Seed	0.048	$2.80	$2.80
3. Herbicide	0.874	$51.05	$51.05
4. Insecticide	0.000	$0.00	$0.00
5. Fertilizer	0.076	$4.45	$4.45
6. Fuel ($0.95/gallon)	0.039	$2.25	$2.25
7. Oil (.15 * fuel)	0.006	$0.34	$0.34
8. Equipment repair	0.039	$2.28	$2.28
9. Custom Hire	0.435	$25.43	$25.43
10. Interest (1/2 Variable Costs @ 14%)	0.115	$6.74	$3.99
A.TOTAL VARIABLE COSTS (Owned land)	$1.65	$96.58	$92.73
TOTAL VARIABLE COSTS (Rented land)**	$1.31	$76.71	$72.86
FIXED COSTS PER ACRE			
11. Real estate taxes ($.50/$100)	0.073	$4.25	$4.25
12. Interest on land	0.873	$51.00	$34.68
13. Share rent (Returns * .333)	0.693	$40.48	$40.48
14. Depreciation on machinery	0.115	$6.73	$0.00
15. Interest on machinery	0.114	$6.69	$2.23
16. Insurance/Housing	0.016	$0.96	$0.96
B.TOTAL FIXED COSTS (Owned land)	$1.19	$69.63	$42.12
TOTAL FIXED COSTS (Rented land)	$0.94	$54.86	$43.67
C.TOTAL COSTS PER ACRE (Owned land)	$2.84	$166.21	$134.84
TOTAL COST PER ACRE (Rented land)	$2.25	$131.57	$116.52
D.YIELD PER ACRE		58.44	
E.PRICE / BUSHEL		$2.08	(3.91/cwt)
F.RETURNS PER ACRE (Row D * Row E)		$121.56	
G.RETURNS OVER VARIABLE COSTS (AVE.)	$0.65	$38.23	$42.08
H.RETURNS OVER TOTAL COSTS (Owned land)	($0.76)	($44.66)	($13.29)
I.RETURNS OVER TOTAL COSTS (Rented land)	($0.17)	($10.02)	$5.03
J.ANNUAL NET RETURNS PER ACRE (AVE.)		($21.55)	($1.07)
K.NET RETURNS TO MANAGEMENT (Row J * Crop Acres)		($11.851.69)	($587.66)

** Assumes landlord pays 1/3 of fertilizer, herbicide, insectide cost on rented land.

Table L.9: ENTERPRISE BUDGET

Conventional Till Wheat-Sorghum-Fallow (CVWSF)
Year 1: Harvest Wheat; Year 2: Plant, Harvest Sorghum;
Year 3: Fallow, Plant Wheat

	Wheat	Sorghum	Total	Cash
VARIABLE COSTS PER ACRE				
1. Labor ($6.00/hr. * .703 hours)	$1.92	$2.86	$4.78	$1.03
2. Seed	$4.50	$2.80	$7.30	$7.30
3. Herbicide	$0.00	$4.10	$4.10	$4.10
4. Insecticide	$0.00	$0.00	$0.00	$0.00
5. Fertilizer	$4.45	$4.45	$8.90	$8.90
6. Fuel ($0.95/gallon)	$2.27	$3.40	$5.67	$5.67
7. Oil (.15 * fuel)	$0.34	$0.51	$0.85	$0.85
8. Equipment repair	$3.77	$4.98	$8.75	$8.75
9. Custom Hire	$19.84	$26.48	$46.32	$46.32
10. Interest (1/2 Variable Costs @ 14%)	$2.77	$3.73	$6.50	$3.73
A. TOTAL VARIABLE COSTS (Owned land)	$39.86	$53.31	$93.17	$86.65
TOTAL VARIABLE COSTS (Rented land)**	$38.25	$50.26	$88.51	$82.00
FIXED COSTS PER ACRE				
11. Real estate taxes ($.50/$100)	$3.19	$3.19	$6.38	$6.38
12. Interest on land	$38.25	$38.25	$76.50	$52.00
13. Share rent (Returns * .333)	$31.83	$43.52	$75.35	$75.35
14. Depreciation on machinery	$9.21	$12.21	$21.42	$0.00
15. Interest on machinery	$9.29	$12.34	$21.63	$7.20
16. Insurance/Housing	$1.33	$1.63	$2.96	$2.96
B. TOTAL FIXED COSTS (Owned land)	$61.27	$67.62	$128.89	$68.54
TOTAL FIXED COSTS (Rented land)	$51.66	$69.70	$121.36	$85.51
C. TOTAL COSTS PER ACRE (Owned land)	$101.13	$120.94	$222.06	155.19
TOTAL COST PER ACRE (Rented land)	$89.91	$119.96	$209.88	167.51

	Wheat	Sorghum	TOTAL	
D. YIELD PER ACRE	30.15	62.84		
E. PRICE / BUSHEL	$3.17	$2.08		
F. RETURNS PER ACRE (Row D * Row E)	$95.58	$130.71	$226.28	
G. RETURNS OVER VARIABLE COSTS (AVE.)	$56.79	$79.43	$136.22	142.74
H. RETURNS OVER TOTAL COSTS (Owned land)	($5.55)	$ 9.77	$4.22	$71.09
I. RETURNS OVER TOTAL COSTS (Rented land)	$5.67	$10.75	$16.41	$58.77
J. ANNUAL NET RETURNS PER ACRE (AVE.)	$1.93	$10.42	$12.35	$62.87

	TOTAL	CASH
K. NET RETURNS TO MANAGEMENT (Total Farm) (Row J * Crop Acres)	$4,528.30	$23,054.12

** Assumes landlord pays 1/3 of fertilizer, herbicide, insectide

Table L.10: ENTERPRISE BUDGET

No Till Wheat-Sorghum-Fallow (NTWSF)
Year 1: Harvest Wheat; Year 2: Plant, Harvest Sorghum;
Year 3: Fallow, Plant Wheat

	Wheat	Sorghum	Total	Cash
VARIABLE COSTS PER ACRE				
1. Labor ($6.00/hr. * .413 hours)	$1.31	$1.30	$2.61	$0.27
2. Seed	$4.50	$2.80	$7.30	$7.30
3. Herbicide	$27.84	$36.90	$64.74	$64.74
4. Insecticide	$0.00	$0.00	$0.00	$0.00
5. Fertilizer	$4.45	$4.45	$8.90	$8.90
6. Fuel ($0.95/gallon)	$0.95	$1.21	$2.16	$2.16
7. Oil (.15 * fuel)	$0.14	$0.18	$0.32	$0.32
8. Equipment repair	$2.03	$2.22	$4.25	$4.25
9. Custom Hire	$20.03	$28.12	$48.15	$48.15
10. Interest (1/2 Variable Costs @ 14%)	$4.59	$5.79	$10.38	$6.12
A. TOTAL VARIABLE COSTS (Owned land)	$65.85	$83.23	$148.81	142.21
TOTAL VARIABLE COSTS (Rented land)**	$55.09	$67.36	$122.45	115.85
FIXED COSTS PER ACRE				
11. Real estate taxes ($.50/$100)	$3.19	$3.19	$6.38	$6.38
12. Interest on land	$38.25	$38.25	$76.50	$52.00
13. Share rent (Returns * .333)	$32.69	$48.24	$80.93	$80.93
14. Depreciation on machinery	$4.54	$4.99	$9.53	$0.00
15. Interest on machinery	$4.50	$4.95	$9.45	$3.32
16. Insurance/Housing	$0.65	$0.78	$1.43	$1.43
B. TOTAL FIXED COSTS (Owned land)	$51.13	$52.08	$103.21	$62.88
TOTAL FIXED COSTS (Rented land)	$42.28	$58.98	$101.26	$85.42
C. TOTAL COSTS PER ACRE (Owned land)	$116.98	$135.04	$252.02	205.09
TOTAL COST PER ACRE (Rented land)	$97.37	$126.34	$223.71	201.28

	Wheat	Sorghum	Total	
D. YIELD PER ACRE	30.97	69.64		
E. PRICE / BUSHEL	$3.17	$2.08		
F. RETURNS PER ACRE (Row D * Row E)	$98.17	$144.85	$243.03	
G. RETURNS OVER VARIABLE COSTS (AVE.)	$39.49	$72.31	$111.80	118.40
H. RETURNS OVER TOTAL COSTS (Owned land)	($18.81)	$9.81	($9.00)	$37.93
I. RETURNS OVER TOTAL COSTS (Rented land)	$1.60	$17.72	$19.32	$41.75
J. ANNUAL NET RETURNS PER ACRE (AVE.)	($5.20)	$15.09	$ 9.89	$40.48

	TOTAL	CASH
K. NET RETURNS TO MANAGEMENT (Total farm) (Row J * Crop Acres)	$3,626.30	$14,842.68

** Assumes landlord pays 1/3 of fertilizer, herbicide, insecticide

Appendix M

Appendix M contains the worksheets used in calculating annual depreciation, insurance, and interest on machinery for each system in the study.

Table M.1: Equipment List Price, Depreciation, Insurance, Interest: CVWF

IMPLEMENT, SIZE	LIST PRICE	DISCOUNT	BEG INDEX	END INDEX	LIFE (YRS)	INTEREST RATE	DEPREC VALUE	SALVAGE VALUE	ANNUAL DEPREC	ANNUAL INSUR	ANNUAL INTEREST
Tractor, 130 HP	$54,400	.30	152	174	10	14%	$33,265	$ 9,813	$ 2,345	$ 333	$ 2,329
Tractor, 110 HP	48,600	.30	152	174	10	14%	29,719	8,767	2,095	297	2,080
V-Blade, 22 ft.	9,625	.20	119	184	14	14%	4,980	538	317	50	349
V-Blade, 18 ft.	8,650	.20	119	184	14	14%	4,475	483	285	45	313
Rodweeder, 25 ft.	7,135	.20	119	184	14	14%	3,692	399	235	37	258
Hoedrill, 24 ft.	14,350	.20	132	184	12	14%	8,236	1,145	591	82	577
TOTAL ANNUAL COST									$ 5,868	$ 844	$ 5,906
PER ACRE COST									$10.67	$ 1.53	$10.73

Table M.2: Equipment List Price, Depreciation, Insurance, Interest: NTWF

IMPLEMENT, SIZE	LIST PRICE	DISCOUNT	BEG INDEX	END INDEX	LIFE (YRS)	INTEREST RATE	DEPREC VALUE	SALVAGE VALUE	ANNUAL DEPREC	ANNUAL INSUR	ANNUAL INTEREST
Tractor, 130 HP	$54,400	.30	152	174	10	14%	$33,265	$ 9,813	$ 2,345	$ 333	$ 2,329
Hoedrill, 24 ft.	14,350	.20	132	184	12	14%	8,236	1,145	591	82	577
Sprayer, 40 ft.	3,800	.20	184	184	14	14%	3,040	328	194	30	213
TOTAL ANNUAL COST									$ 3,130	$ 445	$ 3,119
PER ACRE COST									$ 5.69	$ 0.81	$ 5.67

Table M.3: Equipment List Price, Depreciation, Insurance, Interest: CVWW

IMPLEMENT, SIZE	LIST PRICE	DISCOUNT	BEG INDEX	END INDEX	LIFE (YRS)	INTEREST RATE	DEPREC VALUE	SALVAGE VALUE	ANNUAL DEPREC	ANNUAL INSUR	ANNUAL INTEREST
Tractor, 170 HP	$69,250	.30	152	174	10	14%	$42,346	$12,492	$ 2,985	$ 423	$ 2,964
Tractor, 170 HP	69,250	.30	152	174	10	14%	42,346	12,492	2,985	423	2,964
V-Blade, 22 ft.	9,625	.20	119	184	14	14%	4,980	538	317	50	349
V-Blade, 22 ft.	9,625	.20	119	184	14	14%	4,980	538	317	50	349
Disk, 24 ft.	14,950	.20	184	184	14	14%	11,960	1,292	762	120	837
Disk, 24 ft.	14,950	.20	184	184	14	14%	11,960	1,292	762	120	837
Hoedrill, 50 ft.	23,100	.20	132	184	12	14%	13,257	1,843	951	133	928
TOTAL ANNUAL COST									$ 9,079	$ 1,319	$ 9,228
PER ACRE COST									$ 8.25	$ 1.20	$ 8.39

Table M.4: Equipment List Price, Depreciation, Insurance, Interest: NTWW

IMPLEMENT, SIZE	LIST PRICE	DISCOUNT	BEG INDEX	END INDEX	LIFE (YRS)	INTEREST RATE	DEPREC VALUE	SALVAGE VALUE	ANNUAL DEPREC	ANNUAL INSUR	ANNUAL INTEREST
Tractor, 170 HP	$69,250	.30	152	174	10	14%	$42,346	$12,492	$ 2,985	$ 423	$ 2,964
Hoedrill, 50 ft.	23,100	.20	132	184	12	14%	13,257	1,843	951	133	928
Sprayer, 60 ft.	4,600	.20	184	184	14	14%	3,680	397	234	37	258
TOTAL ANNUAL COST									$ 4,170	$ 593	$ 4,150
PER ACRE COST									$ 3.79	$ 0.54	$ 3.77

Table M.5: Equipment List Price, Depreciation, Insurance, Interest: CVSS

IMPLEMENT, SIZE	LIST PRICE	DISCOUNT	BEG INDEX	END INDEX	LIFE (YRS)	INTEREST RATE	DEPREC VALUE	SALVAGE VALUE	ANNUAL DEPREC	ANNUAL INSUR	ANNUAL INTEREST
Tractor, 170 HP	$69,250	.30	152	174	10	14%	$42,346	$12,492	$ 2,985	$ 423	$ 2,964
Tractor, 130 HP	54,400	.30	152	174	10	14%	33,265	9,813	2,345	333	2,329
Tractor, 110 HP	48,600	.30	152	174	10	14%	29,719	8,767	2,095	297	2,080
V-Blade, 22 ft.	9,625	.20	119	184	14	14%	4,980	538	317	50	349
V-Blade, 18 ft.	8,650	.20	119	184	14	14%	4,475	483	285	45	313
Disk, 24 ft.	14,950	.20	184	184	14	14%	11,960	1,292	762	120	837
Disk, 15 ft.	8,550	.20	184	184	14	14%	6,840	739	436	68	479
Planter, 30 ft.	26,900	.20	184	184	12	14%	21,536	2,994	1,545	215	1,508
Planter, 30 ft.	26,900	.20	184	184	12	14%	21,536	2,994	1,545	215	1,508
Cultivator, 30 ft.	6,060	.20	184	184	14	14%	4,848	524	309	48	339
Cultivator, 15 ft.	3,300	.20	184	184	14	14%	2,640	285	168	26	185
Sprayer, 60 ft.	4,600	.20	184	184	14	14%	3,680	397	234	37	258
TOTAL ANNUAL COST									$12,046	$ 1,896	$13,180
PER ACRE COST									$11.86	$ 1.72	$11.98

Table M.6: Equipment List Price, Depreciation, Insurance, Interest: NTSS

IMPLEMENT, SIZE	LIST PRICE	DISCOUNT	BEG INDEX	END INDEX	LIFE (YRS)	INTEREST RATE	DEPREC VALUE	SALVAGE VALUE	ANNUAL DEPREC	ANNUAL INSUR	ANNUAL INTEREST
Tractor, 130 HP	$54,400	.30	152	174	10	14%	$33,265	$ 9,813	$ 2,345	$ 333	$ 2,329
Tractor, 130 HP	54,400	.30	152	174	10	14%	33,265	9,813	2,345	333	2,329
No till planter	19,560	.20	184	184	12	14%	15,648	2,175	1,123	157	1,095
No till planter	19,560	.20	184	184	12	14%	15,648	2,175	1,123	157	1,095
Sprayer, 40 ft.	3,800	.20	184	184	14	14%	3,040	328	194	30	213
Sprayer, 40 ft.	3,800	.20	184	184	14	14%	3,040	328	194	30	213
TOTAL ANNUAL COST									$ 7,346	$ 1,045	$ 7,299
PER ACRE COST									$ 6.68	$ 0.95	$ 6.64

Table M.7: Equipment List Price, Depreciation, Insurance, Interest: CVSF

IMPLEMENT, SIZE	LIST PRICE	DISCOUNT	BEG INDEX	END INDEX	LIFE (YRS)	INTEREST RATE	DEPREC VALUE	SALVAGE VALUE	ANNUAL DEPREC	ANNUAL INSUR	ANNUAL INTEREST
Tractor, 130 HP	$54,400	.30	152	174	10	14%	$33,265	$ 9,813	$ 2,345	$ 333	$ 2,329
Tractor, 110 HP	48,600	.30	152	174	10	14%	29,719	8,767	2,095	297	2,080
V-Blade, 22 ft.	9,625	.20	119	184	14	14%	4,980	538	317	50	349
V-Blade, 18 ft.	8,650	.20	119	184	14	14%	4,475	483	285	45	313
Disk, 18 ft.	10,900	.20	184	184	14	14%	8,720	942	556	87	610
Disk, 15 ft.	8,550	.20	184	184	14	14%	6,840	739	436	68	479
Planter, 30 ft.	26,900	.20	184	184	12	14%	21,536	2,994	1,545	215	1,508
Cultivator, 30 ft.	6,060	.20	184	184	14	14%	4,848	524	309	48	339
Rodweeder, 25 ft.	7,135	.20	119	184	14	14%	3,692	399	235	37	258
Sprayer, 40 ft.	3,800	.20	184	184	14	14%	3,040	328	194	30	213
TOTAL ANNUAL COST									$ 8,317	$ 1,210	$ 8,478
PER ACRE COST									$15.12	$ 2.20	$15.41

Table M.8: Equipment List Price, Depreciation, Insurance, Interest: NTSF

IMPLEMENT, SIZE	LIST PRICE	DISCOUNT	BEG INDEX	END INDEX	LIFE (YRS)	INTEREST RATE	DEPREC VALUE	SALVAGE VALUE	ANNUAL DEPREC	ANNUAL INSUR	ANNUAL INTEREST
Tractor, 130 HP	$54,400	.30	152	174	10	14%	$33,265	$ 9,813	$ 2,345	$ 333	$ 2,329
No till planter	19,560	.20	184	184	12	14%	15,648	2,175	1,123	157	1,095
Sprayer, 40 ft.	3,800	.20	184	184	14	14%	3,040	328	194	30	213
TOTAL ANNUAL COST									$ 3,702	$ 527	$ 3,682
PER ACRE COST									$ 6.73	$ 0.96	$ 6.69

Table M.9: Equipment List Price, Depreciation, Insurance, Interest: CVWSF

IMPLEMENT, SIZE	LIST PRICE	DISCOUNT	BEG INDEX	END INDEX	LIFE (YRS)	INTEREST RATE	DEPREC VALUE	SALVAGE VALUE	ANNUAL DEPREC	ANNUAL INSUR	ANNUAL INTEREST
Tractor, 170 HP	$69,250	.30	152	174	10	14%	$42,346	$12,492	$ 2,985	$ 423	$ 2,964
Tractor, 110 HP	48,600	.30	152	174	10	14%	29,719	8,767	2,095	297	2,080
Disk, 15 ft.	8,550	.20	184	184	14	14%	6,840	739	436	68	479
Rodweeder, 25 ft.	7,135	.20	119	184	14	14%	3,692	399	235	37	258
V-Blade, 26 ft.	12,500	.20	119	184	14	14%	6,467	698	412	65	453
Hoedrill, 16 ft.	9,560	.20	132	184	12	14%	5,487	763	394	55	384
Planter, 20 ft.	15,430	.20	184	184	12	14%	12,344	1,716	886	123	864
Cultivator, 20 ft.	4,600	.20	184	184	14	14%	3,680	397	234	37	258
Sprayer, 30 ft.	3,450	.20	184	184	14	14%	2,760	298	176	28	193
TOTAL ANNUAL COST									$ 7,853	$ 1,084	$ 7,933
PER ACRE COST									$21.42	$ 2.96	$21.63

Table M.10: Equipment List Price, Depreciation, Insurance, Interest: NTWSF

IMPLEMENT, SIZE	LIST PRICE	DISCOUNT	BEG INDEX	END INDEX	LIFE (YRS)	INTEREST RATE	DEPREC VALUE	SALVAGE VALUE	ANNUAL DEPREC	ANNUAL INSUR	ANNUAL INTEREST
Tractor, 110 HP	$ 48,600	.30	152	174	10	14%	$ 29,719	$ 8,767	$ 2,095	$ 297	$ 2,080
No till planter	14,460	.20	184	184	12	14%	11,460	1,608	830	116	810
Hoedrill, 16 ft.	9,560	.20	132	184	12	14%	5,487	763	394	55	384
Sprayer, 30 ft.	3,450	.20	184	184	14	14%	2,760	298	176	28	193
TOTAL ANNUAL COST									$ 3,495	$ 496	$ 3,467
PER ACRE COST									$ 9.53	$ 1.35	$ 9.45

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ECONOMIC ANALYSIS OF CONVENTIONAL AND NO TILLAGE WHEAT AND GRAIN SORGHUM ROTATIONS IN WEST-CENTRAL, KANSAS WITH RESPECT TO RISK: A STOCHASTIC DOMINANCE APPROACH

By

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Interest in conservation tillage has arisen in recent decades due to the potential for reducing soil erosion as well as economic factors such as reduced energy and labor costs. One type of conservation tillage practice is no-tillage, which replaces tillage with chemical weed control and leaves the surface undisturbed except during planting, when a slot is opened and the seed is dropped into the soil.

Ten conventional and no-tillage wheat and grain sorghum rotations are evaluated in this study, with the analysis including yield, price, and net return variability, as well as analysis of the risk associated with each system. Five conventional and five no-tillage rotations consisting of wheat and grain sorghum in continuous rotations, crop fallow rotations, and in rotation with each other are studied.

Yield data and cropping and tillage practices including variable input levels were obtained from the Fort Hays Branch Experiment Station. These input levels were assumed to be near optimal and that farmers could duplicate the yields on similar cropping systems similar to those being studied at the experiment station. A representative case farm of 1100 crop acres was established using KSU Farm Management Association data for the region. This included tenure arrangements.

An equipment complement was selected for each system based on the field operation needs of the system including tillage and planting operations and chemical applications. Harvesting is assumed to be custom hired, so no equipment was selected for harvesting operations.

The conventional wheat-fallow system was used as a benchmark since this is the most common dryland cropping system used in this area. When adopting alternative cropping systems, additional equipment is added to meet the specific requirements of that system. Attention is given to the type of operation, the timely completion of that operation, and approximate speed and field efficiencies for each implement in determining tractor and implement size for each system.

Enterprise budgets were then constructed for each system. Variable costs and fixed costs were calculated on a per acre basis. Total costs were determined by summing variable and fixed costs. Yield and price data were used to determine gross returns and the total costs were deducted from gross returns to arrive at a value for net returns to management for each system.

Yields, prices, and net returns were examined for variability using standard deviation, coefficient of variation, and also analysis of variance procedures. Stochastic dominance techniques were used to analyze the net returns of each system taking risk into account and sensitivity analysis was used to determine how sensitive the top systems were to yield variations.

Only two systems, conventional and no-till wheat-sorghum-fallow, had positive average net returns to management. Conventional till wheat-sorghum-fallow (CVWSF) had the highest net return followed by no-till wheat-sorghum-fallow (NTWSF). The highest gross returns were found in the conventional till continuous sorghum (CVSS) system and the lowest costs were in the conventional till and no-till wheat-fallow systems, (CVWF) and (NTWF).

The lowest standard deviation of net returns was found in the CVWF system followed closely by NTWF. CVWSF had the lowest positive coefficient of variation, an indication of less risk. NTWF had the least total amount of losses while CVWF had the fewest negative years. The smallest minimum value for a year was in the NTWF system.

Analysis using first degree stochastic dominance eliminated three of the ten systems and second degree stochastic dominance eliminated four more, leaving three systems in the efficient set. Stochastic dominance with respect to a function (SDWRF) was more discriminating, finding that in the risk preferring and risk neutral intervals, the CVWSF system was dominant. In the moderately risk averse range, both CVWSF and NTWF were included in the efficient set. In the more strongly risk averse intervals, NTWF dominated all systems.

Sensitivity analysis revealed that differences between systems were very small and very sensitive to yield variation. In the more risk averse intervals, the yield variation necessary for the NTWF system to no longer dominate was less than the least significant difference in wheat yields for three systems, revealing that the analysis was particularly sensitivity to yield changes.