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ECONOMIC ANALYSIS OF REDUCED TILLAGE WHEAT AND GRAIN SORGHUM ROTATIONS IN WESTERN KANSAS

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ECONOMIC ANALYSIS OF REDUCED-TILLAGE WHEAT AND GRAIN SORGHUM ROTATIONS IN WESTERN KANSAS[1]

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ABSTRACT

Reduced tillage systems for wheat and grain sorghum were compared with conventional systems typical of the central Great Plains. Yield data from the Tribune Branch Experiment Station and season average price data from west central Kansas were used with 1984 cost of production estimates to determine expected returns to a representative 2,000 acre dryland farm for each system. In general, the reduced tillage systems generated higher returns than the other cropping systems considered. Risk analysis revealed that farmers who were risk adverse would likely prefer the reduced tillage wheat-fallow system to conventional systems. Those who were risk neutral would likely prefer the reduced tillage wheat-sorghum-fallow system.

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INTRODUCTION

Overview

Soil moisture is the biggest limiting factor in dryland crop production in western Kansas as well as other areas of the Great Plains. Precipitation ranges from 16 inches in the far west to 23 inches in the west central portion of the state. In addition, this part of the Great Plains has low humidity and high winds, which cause large moisture losses from evaporation. Annual dryland cropping practices result in unstable production during many years across the Great Plains.

The main dryland cropping system in western Kansas historically has been a conventional wheat-fallow rotation. Winter wheat is planted in September and harvested the following June-July. For the next 15 months, the land is fallowed, with shallow cultivation used for weed control. Some of the moisture received during this time is stored in the soil profile for use by the crop in the next growing season.

Many producers are becoming more serious about the adoption of cropping systems to conserve soil moisture and increase yield, along with more cost effective ways of production that increase net farm income, particularly for land that has been fallowed every other year.

Statement of Problem

Fenster et al. (1977) stated that "storing water in the soil during fallow to use for subsequent crop production is the major goal of any fallow system in the Great Plains." Other objectives that contribute to successful fallow and crop production include: (1) preserving crop residues to decrease wind and, to some extent, water erosion; (2) controlling unwanted vegetation during the fallow period; (3) establishing a satisfactory seedbed; (4) if herbicides are used, reducing herbicide residues in the soil and harvested crops; and (5) producing yields and economic returns exceeding those from alternate methods.

Adoption of conservation tillage has increased with the development of more selective chemicals and high capacity, residue grain drills (Retzlaff, 1980). A study compiled by Christensen (1984) revealed that the Great Plains acreage in which some form of conservation tillage was practiced increased from 17,155,000 acres in 1973 to 42,548,000 acres in 1984.

Additionally, more farm managers are considering converting land that is currently under irrigation to dryland. Reasons generally accepted for this are (1) rising energy costs that make irrigated grain production more expensive than it was a decade ago and (2) declining water table levels in parts of the Ogallala Aquifer formation that are making irrigation more economically prohibitive and, in extreme cases, technically impossible. Results of the Ogallala Aquifer Study in Kansas indicate that, compared to 1977 acreages, total irrigated acres harvested in western Kansas were estimated to decline 19 percent by 1985 and 52 percent by 1990 (Kansas Water Office, 1982). Therefore, the amount of land available for dryland tillage practices will be increasing. As irrigation becomes more costly, interest in alternative soil and water conservation practices is expected to rise, along with the need for relevant economic and technical information necessary for widespread adoption of such practices.

Killingsworth and Matulich (1981) argued that soil conservation recommendations to farmers have been largely ignored because economists have emphasized cost effectiveness and neglected other factors underlying their adoption, including the ability to bear risk. Therefore, a study that compares costs and returns of conventional and conservation tillage systems including variability of annual yields and prices will be beneficial to Kansas agricultural producers and related agribusiness.

Objective of Study

The major objective of this study is to evaluate the economic potential and associated risks of conventional and reduced tillage systems for wheat and sorghum in western Kansas. The study will address the following questions: (1) Which cropping system of wheat and/or sorghum has the highest annual net returns in western Kansas? (2) How much risk is involved with each system? (3) What are the cash flow requirements of the most profitable systems?

Specific objectives are:

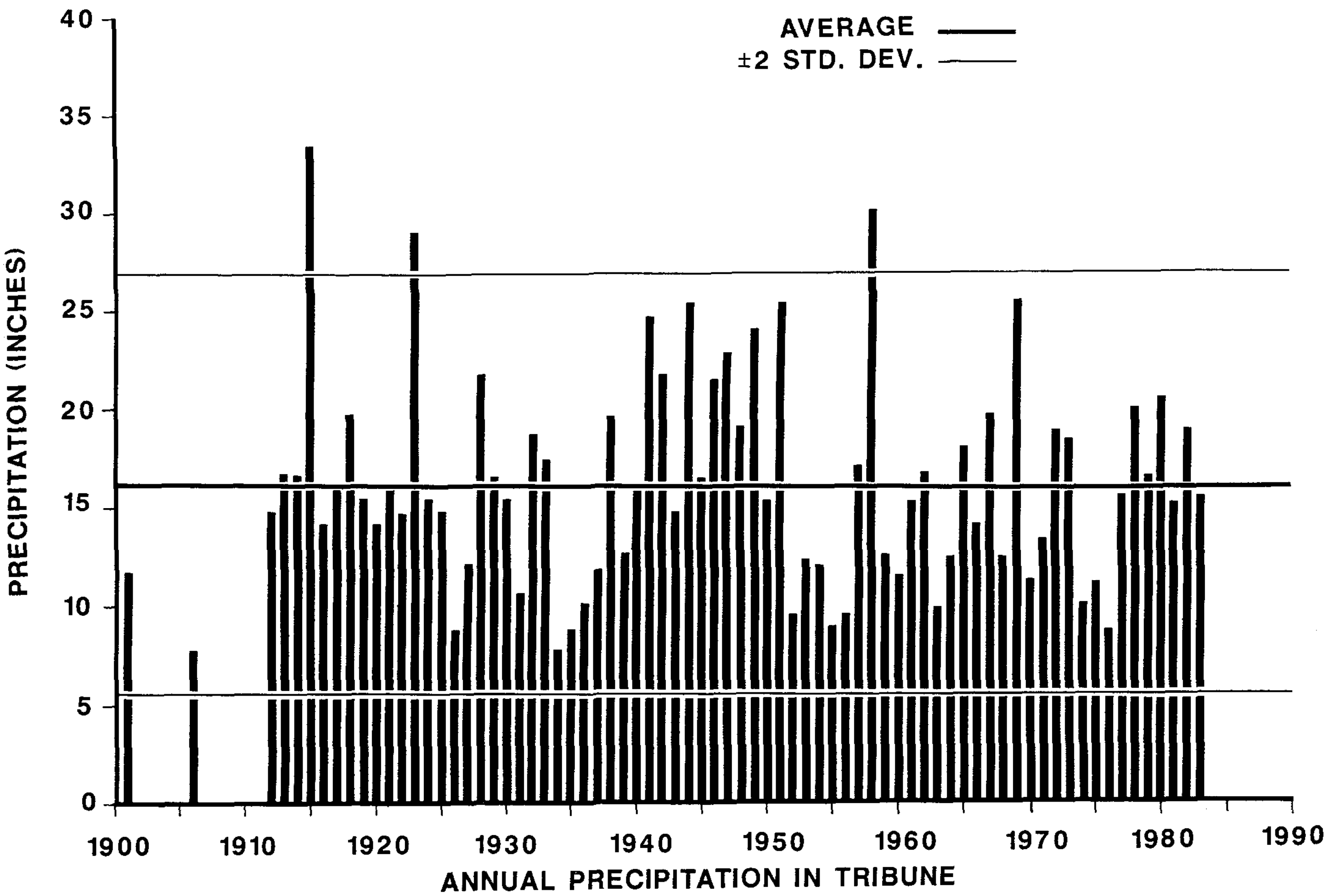
1. To identify technically feasible reduced tillage cropping systems, which could potentially replace conventional tillage systems.
2. With recommendations from agronomists and agricultural experiment station personnel, to establish typical cropping practices that would be followed in each system.
3. To collect yield data from agricultural experiment stations for these cropping systems and their operating practices.
4. To define a representative "case" farm for the study area using Kansas State University Farm Management Data.
5. To establish an equipment complement that is capable of meeting tillage and planting requirements of the case farm within an optimum time period.
6. To estimate the variable and fixed costs for each system based on characteristics of a typical western Kansas farm.
7. To examine potential risk by variance of yields, prices, and net returns for each system over the last 11 years using an enterprise budget framework.
8. To compare cash flow requirements of the most profitable systems.

Study Area Characteristics

Yield data used in this study were collected at the Kansas State University, Tribune Branch Experiment Station, which is located one mile west of Tribune in Greeley County. This county is in western Kansas on the Colorado border, midway between Nebraska and Oklahoma. The land is nearly level to gently rolling and lies between the Arkansas River to the south and the Smoky Hill River to the north. Greeley County has a semi-arid climate characterized by abundant sunshine, low humidity, moderate winds, light precipitation, and wide temperature ranges. Fortunately, 80 percent of the annual precipitation occurs from April through September, the time most favorable for crop growth. The average annual precipitation at the Tribune weather station is 16.2 inches. The variation that can occur in annual precipitation is illustrated in Figure 1.

The thick, fertile silt loam soils on the Tribune Experiment Station are typical of those on about four million acres of the High Plains of western Kansas, eastern Colorado, and the Oklahoma panhandle (Gwin et al., 1974). Soils of Greeley County occur in a pattern closely related to the land topography and can be divided into general areas called soil associations or soil series. Richfield-Ulysses and Ulysses-Colby associations are the major soils.

Figure 1. Annual precipitation in Tribune, Kansas, 1900-1983.



PROCEDURE

Overview

The term "cropping system" is defined in this study as a unique combination of timing of field operations and operating inputs used to produce a grain crop. Significant variations in the number, timing, or quantity of operating inputs and field operations constitute a different cropping system. In 1971, a research project was established at the Tribune Experiment Station to examine the validity of reduced tillage wheat and sorghum cropping systems (Gwin et al. 1984). The experimental plots are on Richfield silt loam soil. Test plots are 27 feet wide and 100 feet long, arranged in a randomized block design with four replications and 14 treatments. Each crop of the sequence is planted in each replication yearly. The first full set of data was reported in 1973, and the experiments are still maintained. The seven cropping systems examined in the Tribune study were analyzed to determine which system provides the greatest net return. The first five systems listed below will be the primary focus of this report:

1. Reduced Tillage Wheat-Sorghum-Fallow (RTWSF), 11 mo. fallow.
2. Conventional Tillage Wheat-Sorghum-Fallow (CVWSF), 11 mo. fallow.
3. Reduced Tillage Wheat-Fallow (RTWF), 15 mo. fallow.
4. Conventional Tillage Wheat-Fallow (CVWF), 15 mo. fallow.
5. Conservation Tillage Sorghum-Fallow (CTSF), 20 mo. fallow.
6. Conventional Tillage Wheat-Wheat (CVWW), 3 mo. fallow.
7. Conventional Tillage Sorghum-Sorghum (CVSS), 6 mo. fallow.

The main differences between systems are the length of the fallow period and the type of weed control. In the reduced tillage systems, mechanical weed control is partially replaced by chemical weed control with herbicides. The sorghum-fallow systems have a 20-month fallow period between crops; wheat-fallow systems 15 months; and wheat-sorghum-fallow systems 11 months. Because of the difference in the fallow period, 6 years are needed to fully compare all systems. The wheat and sorghum fallow systems produce three crops in 6 years, whereas the wheat-sorghum-fallow system provides four crops over 6 years (two wheat and two sorghum crops).

Enterprise budgets are used to analyze the costs and returns of these cropping systems based on a representative farm. These budgets are a means of economically evaluating various crop production systems. The budget formulation is an important part of procedures used in this study. Previous studies have been criticized because the assumptions used in formulating cost estimates were not representative of actual farming units. Therefore, one of the objectives of this research is to provide researchers and farmers with information based on validated figures of existing farms, combined with replicated yield data from an 11-year period.

Variable inputs (seed, fuel, fertilizer, herbicides, etc.,) and general equipment requirements were determined for each cropping system based on Kansas Agricultural Experiment Station practices. Variable and fixed costs with regard to farm size, tenure arrangements, and debt characteristics were estimated and organized in a whole farm enterprise budget. Specifically, labor, fuel, oil, and repair costs were estimated for each individual field operation in the cropping systems and aggregated into an enterprise budget with other associated input costs to determine the expected returns per acre.

Estimated net returns include costs for each crop and corresponding fallowed land associated with each respective crop in the rotation. Gross returns were calculated with the use of annual prices for wheat and grain sorghum from the west central Kansas crop reporting district and 11-year average annual yields from the Tribune Branch Station. Variability of net returns was examined by comparing means, standard deviation, and coefficient of variation statistics. Yearly cash flow needs were summarized with the use of the K-FARM, a computerized cash flow projection program (Barnaby, 1984).

Data from 95 farms in records of the Southwest Kansas Farm Management Association (Parker, 1983) were used to establish the size and tenure of the case farm. The average farm size was assumed to be 2,000 acres. (Actual farm size was 1,926 acres.) Data on land ownership indicated that farmers own 31.9 percent of the total acres they operate. Thus, the case farm will assume 33.3 percent owned (666.66 Ac.) and 66.6 percent rented (1,333.33 Ac.). Farm Management Association data also indicated that area farmers have long-term debts on 24 percent of their owned land (158 Ac.), or approximately a quarter section.

Descriptions of Cropping Systems

Conventional Tillage Wheat-Fallow (CVWF). Table 1 lists the field operations required in the conventional tillage wheat-fallow (CVWF) system in a calendar year. However, this description starts after wheat harvest in June/July, which is the beginning of the fallow period. The stubble is undercut with v-blade sweeps in mid-July to control weed growth and minimize moisture loss from the soil. If additional weeds and volunteer wheat are present in early fall, the stubble will be v-bladed again. This second v-blade tillage operation will occur 75 percent of the time. The wheat stubble lies untouched until the following spring. In 75 percent of the years, the land will be tilled with a disk in early May, especially if there is heavy stubble. In early June and mid-July, the fallowed land will be v-bladed, then rodweeded in August and early September. The conventional wheat-fallow system averages 1.75 tillage operations between harvest and winter. During the following spring and summer, the land is tilled 4.75 times on the average, resulting in 6.5 tillage operations to produce a crop. Forty lbs/acre of wheat seed is drilled in early September. In March of the next crop year, the growing wheat is fertilized with dry granulated ammonium nitrate fertilizer, to obtain 30 units of nitrogen per acre. The wheat matures in June and is harvested in June/July depending on weather conditions. Then the 2-year cycle is repeated for the next crop.

Reduced Tillage Wheat-Fallow (RTWF). After wheat harvest, stubble is treated with ¾ lb. atrazine and v-bladed (Table 2). The atrazine will control most broadleaf and selected grass weeds until early summer of the next year. This eliminates 2.5 of the tillage operations needed compared to the conventional wheat-fallow system. The land is v-bladed in June and July, then rodweeded in August for weed control and seedbed preparation. Wheat is planted in September, fertilized with 30 units of nitrogen in March, and harvested in June/July.

Conventional Tillage Wheat-Sorghum-Fallow (CVWSF). This rotation is identical to the conventional wheat-fallow system in preparing a wheat seedbed, planting, and harvesting. The major difference is that the additional sorghum crop is planted the next summer, 11 months after wheat harvest (Table 3). The wheat stubble is disked twice to prepare the sorghum seedbed. The nitrogen rate is adjusted to 22.5 units N, because of the difference in the cropping cycle. Nitrogen is applied as ammonium nitrate before the second disking. Sorghum seed (1.75 Ibs.) is planted in 30-inch rows during late May/early June. The sorghum is cultivated and 2,4-D is applied 33 percent of the time for weed control. There is a second cultivation 50 percent of the time and parathion is applied for greenbug control in 33 percent of the years. The sorghum is harvested in October. The following year, the land is disked 75 percent of the time in May, v-bladed in June and July, then rodweeded in August and early September to prepare a seedbed. Forty Ibs. of wheat seed are planted approximately on September 10. The crop is fertilized in March with 22.5 units N and harvested in June/July. The 3-year cycle then repeats itself.

Reduced Tillage Wheat-Sorghum-Fallow (RTWSF). Following wheat harvest, 1.25 pounds/acre of atrazine are applied in addition to v-blading (Table 4). Twenty-two and one half Ibs. of nitrogen are applied in April and incorporated with a disk. Sorghum is planted in early June. The sorghum, which is cultivated once in July, requires an application of 2,4-D 25 percent of the time for weed control, and needs an application of parathion for greenbug control in 33 percent of the years. Sorghum harvest occurs in October. During the next year, the land is mechanically tilled with v-blades in June and July, then rodweeded in August. Wheat is planted in September, fertilized with 22.5 Ibs. of nitrogen in March, and harvested in June/July.

Conservation Tillage Sorghum-Fallow (CTSF). The conservation sorghum-fallow system is similar to a conventional sorghum-fallow system except for some additional conservation measures used during the 20-month fallow period. Planting occurs in early June, then 1 lb. of atrazine is applied as indicated in Table 5. The sorghum, which is cultivated once in July, requires an application of 2,4-D for weed control and a parathion application for greenbug control in 33 percent of the years. The sorghum is harvested in October. Following sorghum harvest, stalks are allowed to stand in the field to provide moisture conservation until the following spring. Beginning in May, the soil is undercut with a v-blade, followed with a disking in June. In July, a v-blade is used and in August a rodweeder is used to control weeds through the remainder of the summer fallow period. In the fall, 6-8 inch furrows are formed with a lister to reduce wind erosion. During the following spring, beds formed by the lister are reshaped with a Lilliston rolling cultivator. Thirty Ibs. of nitrogen are applied in April. In one-half of the years, the beds are covered again with the Lilliston cultivator to prepare a seedbed for June planting.

Table 1. Field Operations Required for Conventional Wheat-Fallow (CVWF)

FIELD OPERATION		DATE		YEAR	ANNUAL ACRES
Disk	(75%)	May	1	I	750
V-Blade		June	5	I	1,000
V-Blade		July	15	I	1,000
RodWeed		Aug	12	I	1,000
RodWeed		Sept	1	I	1,000
Hoe Drill		Sept	10	I	1,000
Apply Nitrogen		March	1	II	1,000
Harvest Wheat		June	30	II	1,000
V-Blade		July	10	II	1,000
V-Blade	(75%)	Oct	1	II	750
				Total	9,500

Table 2. Field Operations Required for Reduced Tillage Wheat-Fallow (RTWF)

FIELD OPERATION	DATE		YEAR	ANNUAL ACRES
V-Blade	June	5	I	1,000
V-Blade	July	20	I	1,000
RodWeed	Aug	20	I	1,000
Hoe Drill	Sept	10	I	1,000
Apply Nitrogen	March	1	II	1,000
Harvest Wheat	June	30	II	1,000
Apply Atrazine	July	10	II	1,000
V-Blade	July	10	II	1,000
			Total	8,000

Table 3. Field Operations Required for Conventional Wheat-Sorghum-Fallow (CVWSF)

FIELD OPERATION		DATE		YEAR	ANNUAL ACRES
Disk	(75%)	May	1	I	500
V-Blade		June	5	I	667
V-Blade		July	15	I	667
RodWeed		Aug	12	I	667
RodWeed		Sept	1	I	667
Hoe Drill		Sept	10	I	667
Apply Nitrogen		March	1	II	667
Harvest Wheat		June	30	II	667
V-Blade		July	10	II	667
V-Blade	(75%)	Oct	1	II	500
Apply Nitrogen		April	25	III	667
Disk		April	29	III	667
Disk		May	20	III	667
Plant Sorghum		June	1	III	667
Cultivate		July	12	III	667
Spray 2,4-D	(33%)	July	15	III	222
Cultivate	(50%)	July	30	III	333
Parathion	(33%)	Aug	1	III	222
Harvest Sorghum		Oct	8	III	667
				Total	11,115

Table 4. Field Operations Required for Reduced Tillage Wheat-Sorghum-Fallow (RTWSF)

FIELD OPERATION		DATE		YEAR	ANNUAL ACRES
V-Blade		June	5	I	667
V-Blade		July	20	I	667
RodWeed		Aug	20	I	667
Hoe Drill		Sept	10	I	667
Apply Nitrogen		March	1	II	667
Harvest Wheat		June	30	II	667
Apply Atrazine		July	10	II	667
V-Blade		July	10	II	667
Apply Nitrogen		April	25	III	667
Disk		May	1	III	667
Plant Sorghum		June	1	III	667
Cultivate		July	12	III	667
Spray 2,4-D	(25%)	July	15	III	167
Parathion	(33%)	Aug	1	III	222
Harvest Sorghum		Oct	8	III	667
				Total	9,060

Table 5. Field Operations Required for Conservation Tillage Sorghum-Fallow (CTSF)

FIELD OPERATION		DATE		YEAR	ANNUAL ACRES
V-Blade		May	1	I	1,000
Disk		June	5	I	1,000
V-Blade		July	15	I	1,000
RodWeed		Aug	12	I	1,000
List Beds		Oct	20	I	1,000
Lilliston Cult.		April	20	II	1,000
Apply Nitrogen		April	25	II	1,000
Lilliston Cult.	(50%)	May	15	II	500
Plant Sorghum		June	1	II	1,000
Apply Atrazine		June	5	II	1,000
Cultivate		July	12	II	1,000
Spray 2,4-D	(33%)	July	15	II	333
Parathion	(33%)	Aug	1	III	333
Harvest Sorghum		Oct	8	III	1,000
				Total	12,166

ENTERPRISE BUDGET FORMAT AND ASSUMPTIONS

Enterprise budgets fashioned after Krause and Langemeier (1984) are used to summarize all the annual operating expenses and machinery costs for analysis purposes (Tables 6-10). The budgets are divided into two main sections using cash cost and total cost columns: (1) variable costs and (2) fixed costs. Yields, prices, and returns are also indicated. In addition, costs for owned and rented land are separated for comparative purposes.

In Tables 6-10, letter B indicates the total fixed costs. For owned land, it is the sum of items 11, 12, 14, 15, and 16. Rented land combines items 13 through 16. Total costs (letter C) are simply total variable costs plus total fixed costs.

Variable Costs

1. Labor. The total labor costs are computed by multiplying the sum of the hours required to complete field operations (adjusted for field efficiencies) by a $6.00 per hour wage rate.

2. Seed. Seed expense is calculated by determining the seeding rate (lbs/acre) and multiplying it by the appropriate cost per pound of seed. Wheat is planted at 40 lbs/acre and is priced at $0.10/lb. Sorghum is planted at 1.75 lbs/acre and is priced at $1.25/lb.

3. Herbicide, 4. Insecticide, and 5. Fertilizer. Herbicide, insecticide, and fertilizer costs are calculated by multiplying the application rate per acre times the per unit cost of the chemical. (In figuring variable costs for rented land, one third of the fertilizer, herbicide, and insecticide costs are shared by the landlord.) Herbicide and fertilizer application rates were recommended by Roy Gwin, Head, Tribune Branch Station, who conducted the actual studies. Nitrogen reported in this study was held constant at an annual rate of 15 lbs/acre and priced at $.27 per lb. of N. Herbicides, insecticides and other fertilizers are assumed to be custom applied at an average of $3.00/acre (Kansas Crop and Livestock Rep. Serv., 1984).

6. Fuel and 7. Oil. Fuel consumption as gallons per acre was obtained from a survey of Kansas agricultural procedures (Schrock et al., 1986). The fuel price used is the January 1984 average price in cents per gallon for No. 2 Diesel ($0.95), excluding tax (USDA, 1985). Oil and lubricant cost is assumed to be 15 percent of the fuel cost.

8. Equipment Repair. Repair costs are based on the number of hours the tractor and tillage implement are used in each field operation. Repair cost parameters based on hours of use were obtained from Rotz, 1985.

9. Custom Hire (Harvest Expense). Harvesting expenses are listed as custom hire, and are based on hiring custom harvesters. Custom rates for harvest are assumed to be $13.00/acre plus $0.13/bushel for each bushel above 20 bushels/acre for wheat, and 30 bushels/acre for sorghum. The custom rate for hauling to storage is $0.13/bushel.

10. Interest. Interest expense on variable cost is calculated as 15 percent interest on one-half the sum of the variable cost items. The cash column for the variable cost portion of the summary is the same as the total expense, except for labor and interest. It is assumed that the farm will be operated by one man with one summer employee paid a wage of $6.00 per hour. Therefore, cash for labor is only paid when hired labor is completing tillage operations. Actual cash interest expense is assumed to be 60 percent of the total interest expense (Krause and Langemeier, 1984).

Fixed Costs

11. Real Estate Taxes and 12. Land Interest. The second section of the summary enterprise budget lists the fixed costs associated with the cropping system. Real estate taxes are $0.50/acre for each $100.00 of land value, which is assumed to be $400.00/acre. Interest on the land is calculated using a 6 percent interest rate (Krause and Langemeier, 1984). However, it takes 2 years of land management to produce one full crop in the wheat-fallow and sorghum-fallow systems. Therefore, the ownership costs are doubled to properly allocate expenses for actual crop acres on an annual basis. In the wheat-sorghum-fallow system, 3 years of land management produces annual crops of wheat and sorghum, so the ownership expenses are tripled in this system. The annual, owned land, opportunity cost for each system is $16,000. The actual cash payment for land in the cash column is the estimated land payment using a 12 percent interest rate for land financing. These assumptions are based on the KSU farm management guides for comparative budgeting.

13. Share Rent. Share rent to the landlord occurs with the rented acres in the representative farm and is included as an expense. It is figured by multiplying one-third of the yield by the average price.

Table 6. Conventional Wheat-Fallow (CVWF) Enterprise Budget

COSTS AND RETURNS	TOTAL	CASH
VARIABLE COSTS PER ACRE		
1. Labor $6/Hr. x 0.389 Hrs.	$ 2.34	$ 0.60
2. Seed	4.00	4.00
3. Herbicide	0.00	0.00
4. Insecticide	0.00	0.00
5. Fertilizer*	11.10	11.10
6. Fuel ($/Gallon)=$0.95	4.57	4.57
7. Oil	0.69	0.69
8. Equipment Repair	4.88	4.88
9. Custom Hire (Harvest Exp)	18.55	18.55
10. Interest (1/2 VC @ 15%)	3.46	2.08
A. TOTAL VARIABLE COSTS (Owned Land)	49.58	46.47
TOTAL VARIABLE COSTS (Rented Land)	45.92	42.80
FIXED COST PER ACRE		
11. Real Estate Taxes ($.50/$100)	$ 8.00	8.00
12. Interest on Land (160 Acres) ($400/A x 2 x 6%) (24% LT DEBT @ 12% i)	48.00	24.48
13. Share Rent (Returns x 33%)	34.34	34.34
14. Depreciation on Machinery	10.59	0.00
15. Interest on Machinery	12.34	4.07
16. Insurance and Housing	1.65	1.65
B. TOTAL FIXED COSTS (Owned Land)	80.58	38.20
TOTAL FIXED COSTS (Rented Land)	58.92	40.06
C. TOTAL COSTS PER ACRE (Owned Land)	130.16	84.67
TOTAL COST PER ACRE (Rented Land)	104.84	82.86
D. YIELD PER ACRE (Bu)	31.34	—
E. PRICE/BUSHEL	$ 3.29	—
F. GROSS RETURN PER ACRE	103.11	—
G. RETURNS OVER VARIABLE COSTS (Avg.)	55.98	60.30
H. RETURNS OVER TOTAL COSTS (Owned Land)	-27.05	18.44
I. RETURNS OVER TOTAL COSTS (Rented Land)	- 1.73	20.25
J. ANNUAL NET RETURNS PER AC. (Avg.)	-10.09	19.65
K. NET RETURN TO MANAGEMENT (Total Farm) (1,000 acres wheat, 1,000 acres fallow)	-10,085	—

*Assumes landlord paying 1/3 of fertilizer expense ($3.66) on 1333.33 acres of rented land.

Table 7. Reduced Tillage Wheat-Fallow (RTWF) Enterprise Budget

COSTS AND RETURNS	TOTAL	CASH
VARIABLE COSTS PER ACRE		
1. Labor $6/Hr. x 0.266 Hrs.	$ 1.60	$ 0.45
2. Seed	4.00	4.00
3. Herbicide*	5.14	5.14
4. Insecticide	0.00	0.00
5. Fertilizer*	11.10	11.10
6. Fuel ($/Gallon)=$0.95	2.97	2.97
7. Oil	0.45	0.45
8. Equipment Repair	3.77	3.77
9. Custom Hire (Harvest Exp)	20.34	20.34
10. Interest (1/2 VC @ 15%)	3.70	2.22
A. TOTAL VARIABLE COSTS (Owned Land)	53.06	50.43
TOTAL VARIABLE COSTS (Rented Land)	47.71	45.07
FIXED COST PER ACRE		
11. Real Estate Taxes ($.50/$100)	$ 8.00	8.00
12. Interest on Land (160 Acres) ($400/A x 2 x 6%) (24% LT DEBT @ 12% i)	48.00	24.48
13. Share Rent (Returns x 33%)	41.87	41.87
14. Depreciation on Machinery	10.59	0.00
15. Interest on Machinery	12.34	4.07
16. Insurance and Housing	1.65	1.65
B. TOTAL FIXED COSTS (Owned Land)	80.58	38.20
TOTAL FIXED COSTS (Rented Land)	66.45	47.59
C. TOTAL COSTS PER ACRE (Owned Land)	133.64	88.64
TOTAL COST PER ACRE (Rented Land)	114.16	92.67
D. YIELD PER ACRE (Bu)	38.22	—
E. PRICE/BUSHEL	$ 3.29	—
F. GROSS RETURN PER ACRE	125.74	—
G. RETURNS OVER VARIABLE COSTS (Avg.)	76.27	75.31
H. RETURNS OVER TOTAL COSTS (Owned Land)	- 7.90	37.11
I. RETURNS OVER TOTAL COSTS (Rented Land)	11.58	33.07
J. ANNUAL NET RETURNS PER AC. (Avg.)	5.15	34.41
K. NET RETURN TO MANAGEMENT (Total Farm) (1,000 acres wheat, 1,000 acres fallow)	5,154	—

*Assumes landlord paying 1/3 of herbicide ($1.70) and fertilizer ($3.66) costs on 1333.33 acres of rented land.

Table 8. Conventional Wheat-Sorghum-Fallow (CVWSF) Enterprise Budget

	WHEAT		SORGHUM	
COSTS AND RETURNS	TOTAL	CASH	TOTAL	CASH
VARIABLE COSTS PER ACRE				
1. Labor $6/Hr.	$ 2.23	$ 0.60	2.26	1.03
2. Seed	4.00	4.00	2.19	2.19
3. Herbicide*	0.00	0.00	1.63	1.63
4. Insecticide*	0.00	0.00	1.29	1.29
5. Fertilizer*	9.08	9.08	9.08	9.08
6. Fuel ($/Gallon)=$0.95	4.58	4.58	2.69	2.69
7. Oil	0.68	0.68	0.40	0.40
8. Equipment Repair	4.87	4.87	3.29	3.29
9. Custom Hire (Harvest Exp)	18.30	18.30	19.54	19.54
10. Interest (1/2 VC @ 15%)	3.28	1.97	3.17	1.90
TOTAL	47.02	44.08	45.54	43.04
A. TOTAL VARIABLE COSTS (Owned Land)	92.56	87.12		
TOTAL VARIABLE COSTS (Rented Land)	85.93	80.49		
FIXED COST PER ACRE				
11. Real Estate Taxes ($.50/$100 x 3)	$ 12.00	12.00		
12. Interest on Land ($400/A x 3 x 6%) (24% LT DEBT @ 12% i)	72.00	36.72		
13. Share Rt. WHT. (Returns x 33%)	33.27	33.27		
Share Rt. SOR. (Returns x 33%)	30.61	30.61		
14. Depreciation on Machinery	19.22	0.00		
15. Interest on Machinery	21.94	7.24		
16. Insurance and Housing	2.96	2.96		
B. TOTAL FIXED COSTS (Owned Land)	128.12	58.92		
TOTAL FIXED COSTS (Rented Land)	108.01	74.09		
C. TOTAL COSTS PER ACRE (Owned Land)	220.68	146.04		
TOTAL COST PER ACRE (Rented Land)	193.94	154.58		
D. YIELD PER ACRE (Bu)	30.37		40.16	
E. PRICE/BUSHEL	$ 3.29		2.31	
F. GROSS RETURN PER ACRE	99.92		92.77	192.69 Total
G. RETURNS OVER VARIABLE COSTS (Avg.)	104.57		110.01	
H. RETURNS OVER TOTAL COSTS (Owned Land)	-27.99		46.65	
I. RETURNS OVER TOTAL COSTS (Rented Land)	- 1.25		38.11	
J. ANNUAL NET RETURNS PER AC. (Avg.)	-10.08		40.92	
K. NET RETURN TO MANAGEMENT (Total Farm) (666.66 acres wheat, 666.66 acres sorghum, 666.66 fallow)	-6,717			

*Assumes landlord paying 1/3 of herbicide ($0.21), insecticide ($0.43), and fertilizer ($5.98) costs on 1333.33 acres of rented land.

Table 9. Reduced Tillage Wheat-Sorghum-Fallow (RTWSF) Enterprise Budget

	WHEAT		SORGHUM	
COSTS AND RETURNS	TOTAL	CASH	TOTAL	CASH
VARIABLE COSTS PER ACRE				
1. Labor $6/Hr. x 0.531 Hrs.	$ 1.60	$ 0.45	$ 1.59	$ 0.25
2. Seed	4.00	4.00	2.19	2.19
3. Herbicide*	6.56	6.56	1.24	1.24
4. Insecticide*	0.00	0.00	1.29	1.29
5. Fertilizer*	9.08	9.08	9.08	9.08
6. Fuel ($/Gallon)=$0.95	3.09	3.09	1.67	1.67
7. Oil	0.53	0.53	0.13	0.13
8. Equipment Repair	3.75	3.75	2.81	2.81
9. Custom Hire (Harvest Exp)	20.00	20.00	22.87	22.87
10. Interest (1/2 VC @ 15%)	3.64	2.18	3.21	1.94
TOTAL	52.31	49.64	46.08	43.46
A. TOTAL VARIABLE COSTS (Owned Land)	98.34	93.10		
TOTAL VARIABLE COSTS (Rented Land)	89.35	84.11		
FIXED COST PER ACRE				
11. Real Estate Taxes ($.50/$100 x 3)	$ 12.00	12.00		
12. Interest on Land ($400/A x 3 x 6%) (24% LT DEBT @ 12% i)	72.00	36.72		
13. Share Rt. WHT. (Returns x 33%)	40.08	40.08		
Share Rt. SOR. (Returns x 33%)	40.39	40.39		
14. Depreciation on Machinery	19.22	0.00		
15. Interest on Machinery	21.94	7.24		
16. Insurance and Housing	2.96	2.96		
B. TOTAL FIXED COSTS (Owned Land)	128.12	58.92		
TOTAL FIXED COSTS (Rented Land)	124.59	90.67		
C. TOTAL COSTS PER ACRE (Owned Land)	226.46	152.02		
TOTAL COST PER ACRE (Rented Land)	213.94	174.78		
D. YIELD PER ACRE (Bu)	36.92		52.98	
E. PRICE/BUSHEL	$ 3.29		2.31	
F. GROSS RETURN PER ACRE	121.47		122.38	243.85 Total
G. RETURNS OVER VARIABLE COSTS (Avg.)	151.53		150.75	
H. RETURNS OVER TOTAL COSTS (Owned Land)	17.39		91.83	
I. RETURNS OVER TOTAL COSTS (Rented Land)	29.91		69.07	
J. ANNUAL NET RETURNS PER AC. (Avg.)	25.78		76.58	
K. NET RETURN TO MANAGEMENT (666.66 acres wheat, 666.66 acres sorghum, 666.66 fallow)	17,186			

*Assumes landlord paying 1/3 of herbicide ($2.57), insecticide ($0.43), and fertilizer ($5.98) costs on 1333.33 acres of rented land.

Table 10. Conservation Tillage Sorghum-Fallow (CTSF) Enterprise Budget

COSTS AND RETURNS	TOTAL	CASH
VARIABLE COSTS PER ACRE		
1. Labor $6/Hr. x 0.656 Hrs.	$ 3.94	$ 1.11
2. Seed	2.19	2.19
3. Herbicide*	7.48	7.48
4. Insecticide*	1.29	1.29
5. Fertilizer*	11.10	11.10
6. Fuel ($/Gallon)=$0.95	4.55	4.55
7. Oil	0.68	0.68
8. Equipment Repair	4.45	4.45
9. Custom Hire (Harvest Exp)	25.90	25.90
10. Interest (1/2 VC @ 15%)	4.41	2.64
A. TOTAL VARIABLE COSTS (Owned Land)	65.98	61.40
TOTAL VARIABLE COSTS (Rented Land)	59.75	55.17
FIXED COST PER ACRE		
11. Real Estate Taxes	$ 8.00	8.00
12. Interest on Land ($400/A x 2 x 6%) (24% LT DEBT @ 12% i)	48.00	24.48
13. Share Rent (Returns x 33%)	49.70	49.70
14. Depreciation on Machinery	11.12	0.00
15. Interest on Machinery	13.00	4.29
16. Insurance and Housing	1.77	1.77
B. TOTAL FIXED COSTS (Owned Land)	81.89	38.54
TOTAL FIXED COSTS (Rented Land)	75.59	55.76
C. TOTAL COSTS PER ACRE (Owned Land)	147.87	99.94
TOTAL COST PER ACRE (Rented Land)	135.34	110.93
D. YIELD PER ACRE (Bu)	64.61	—
E. PRICE/BUSHEL	$ 2.31	—
F. GROSS RETURN PER ACRE	149.25	—
G. RETURNS OVER VARIABLE COSTS (Avg.)	87.44	94.08
H. RETURNS OVER TOTAL COSTS (Owned Land)	1.38	49.31
I. RETURNS OVER TOTAL COSTS (Rented Land)	13.91	38.32
J. ANNUAL NET RETURNS PER AC. (Avg.)	9.77	41.95
K. NET RETURN TO MANAGEMENT (Total Farm) (1,000 acres wheat, 1,000 acres fallow)	9,771	—

*Assumes landlord paying 1/3 of herbicide ($2.14), insecticide ($0.43), and fertilizer ($3.66) costs on 1333.33 acres of rented land.

14-16. Machinery Costs. Machinery ownership costs of depreciation, interest, and insurance/housing are listed in items 14, 15, and 16, respectively. Depreciation estimates are based on the original purchase price, which is estimated as 85 percent of list price. For equipment that would already exist in a conventional wheat-fallow cropping system, age was assumed to be one-half of its depreciable life. Sorghum planting equipment was assumed to be new, because it would have to be purchased for any rotation with sorghum. Depreciable life was determined to be 10 years for tractors, 12 years for planters, and 14 years for tillage implements. Therefore, tractors were assumed to be 5 years old, planters 6 years old, and tillage implements 7 years old. To find the purchase price for each implement, the 1984 list price (Table 11) was discounted by a ratio of price indexes for tractors and implements for the appropriate year (USDA, 1978-1984). The beginning depreciable base and the year the equipment was assumed to have been purchased are also listed in Table 11. Salvage values are estimated as a percentage of purchase price (Mohasci et al., 1982).

Tractor and implement list prices (1984$) are based on information received from western Kansas equipment dealers and the Hot Line Farm Equipment Guide (Hot Line Inc., 1985). List prices for several brands were averaged to obtain an overall list price.

Depreciation is calculated using a straight-line basis, which is required for enterprise budgets. The depreciable base value is listed in Table 11 for each piece of equipment. Interest expense on machinery is based on the average value of the equipment over its life. The interest rate used for this calculation is 15 percent. Insurance and housing are estimated to be 1 percent of the depreciable base (purchase price). Once the annual fixed costs of the equipment are estimated, the per acre cost is calculated by dividing annual ownership cost by 2,000 acres. Total acres are used because the fallow systems require more than one acre of land for each acre of crop on an annual basis for calculating costs. Depreciation and interest costs are then adjusted to a crop-acre basis in the enterprise budgets to correspond with the land ownership cost allocation.

Machinery Complement

One requirement for using enterprise budgets to evaluate different cropping systems is selecting combinations of tractors and implements. Tractors and implements must be selected for each field operation, based on the tillage and planting requirements of the systems. The cost of a field operation may be influenced by which tractor-implement combination is selected. An agricultural engineering worksheet (Schrock, 1976) was used to determine power take-off horsepower (PTO H.P.) needed for the tractors, along with consideration of total farm size, planting, and tillage constraints (Peterson 1981, Wilkins, 1978), plus available field work days (Buller et al., 1976). The equipment was selected to meet optimal requirements in 85 percent of the years. This timeliness level leads to one 234 H.P. four-wheel drive and one 184 H.P. two-wheel drive tractor with their corresponding planting and tillage implements for the majority of the cropping systems (Table 11).

Yields and Prices

Crop yields are the average from test plot replications at the Tribune Branch Station from 1973-1984. Crop prices are the annual average from the west central district of the Kansas Crop and Livestock Reporting Service. This was assumed to be representative of prices received by farmers and, thus, useful for comparative purposes (Table 12).

Returns

In Tables 6-10, gross returns (F) are calculated by multiplying yield (D) in bushels per acre times the average price (E). Net returns over variable costs (G) are calculated by subtracting total variable costs (A) from returns per acre (F). Net returns over total costs for rented and owned land are calculated by subtracting total costs (C) from returns per acre (F). Annual returns per acre (J) represent weighted returns over total costs, with 67 percent from rented land and 33 percent from owned land. Net returns to management are calculated by multiplying (J) by the number of crop acres: 1,000 acres for wheat-fallow and sorghum-fallow systems, 666 acres of wheat and sorghum in wheat-sorghum-fallow systems, and 2,000 acres in continuous wheat and sorghum systems. Returns must be compared on a total farm basis to reflect the differences in crop and fallow acres. It should be noted that all labor costs, interest expenses, and a return to owned land have been deducted from the net return to management.

Table 11. Equipment List Price, Depreciable Base, and Year Purchased

IMPLEMENT, SIZE	LIST PRICE	DEPRECIABLE BASE	YEAR PURCHASED
1. 4WD Tractor, 234 H.P.	$99,600	$62,916	1979
2. 2WD Tractor, 184 H.P.	$64,100	$40,491	1979
3. Disk, 27 ft	$17,300	$ 8,079	1977
4. Disk, 20 ft	$12,200	$ 5,697	1977
5. V-Blade, 42 ft	$29,900	$13,964	1977
6. V-Blade, 30 ft	$23,400	$10,928	1977
7. Rodweeder, 48 ft	$13,500	$ 6,304	1977
8. Rodweeder, 36 ft	$ 8,800	$ 4,109	1977
9. Cultivator, 30 ft	$11,500	$ 5,370	1977
10. Lilliston, 30 ft	$13,800	$ 6,960	1977
11. Bedder, 30 ft	$ 5,000	$ 2,521	1977
12. Planter, 30 ft	$25,600	$21,760	1984
13. Hoe Drill, 40 ft	$35,200	$17,754	1978
14. Hoe Drill, 50 ft	$52,700	$26,581	1978

Table 12. Crop Prices ($ per bushel), Annual Average, Kansas West Central District

YEAR	WHEAT	SORGHUM
1973	$3.55	$2.19
1974	$3.99	$3.01
1975	$3.39	$2.27
1976	$2.56	$1.80
1977	$2.17	$1.73
1978	$2.80	$1.98
1979	$3.62	$2.13
1980	$3.67	$2.80
1981	$3.61	$2.24
1982	$3.46	$2.26
1983	$3.40	$2.67
AVG.	$3.29	$2.31

ANALYSIS

Annual Field Operations

The major difference between the cropping systems (in addition to the length of the fallow period) is the combination of tillage operations and chemical applications. Table 13 summarizes annual crop acres and the field operations required to complete each cropping system. The reduced tillage wheat-fallow (RTWF) system has 2.5 fewer tillage operations when compared with conventional wheat-fallow (CVWF), but requires an additional herbicide application. Thus, the net result is 1,500 less acres covered annually by field operations for RTWF versus CVWF. Because of the additional sorghum crop, the conventional tillage wheat-sorghum-fallow (CVWSF) rotation requires substantially more field operations (7.1) when compared with the CVWF systems. However, the actual farming units are 666.6 acres per crop in the wheat-sorghum-fallow systems, compared to 1,000 acres in the wheat-fallow and sorghum-fallow systems. Thus, the resulting annual acres covered do not increase proportionally. For example, the conventional tillage wheat-sorghum-fallow system (CVWSF) requires 16.6 total operations versus 9.5 in the conventional wheat-fallow system (CVWF). However, field operations in CVWSF cover only 1,615 more acres annually than those in the CVWF system.

Results by Cropping System

Reduced tillage wheat-sorghum-fallow (RTWSF) generated the highest average net return to management of $17,186, as shown in Table 14. This figure represents income from 666.66 acres of wheat and 666.66 acres of sorghum, minus the combined production expenses summed from 666 acres of wheat, 666 acres sorghum, and 666 acres of fallow land. The RTWSF system had lower labor, fuel, and repair costs by $3,885, but increased chemical costs of $3,056 when compared with the CVWSF system (Table 15). The reduced tillage systems costs were slightly less. The net return was higher for the reduced tillage system than the conventional system, mainly because of increased crop yields.

Conservation sorghum-fallow (CTSF) generated the second highest net returns of $9,771. Included in this figure are the gross returns from 1,000 acres of sorghum minus expenses from the crop and fallow land managed that year. The system incurred $1,599 more labor costs and $7,057 more in chemicals than the CVWF system. However fuel, oil, and repair costs were $453 less.

Reduced tillage wheat-fallow (RTWF) had the third largest net return of $5,154. This figure accounts for costs and returns for 1,000 acres of wheat crop and 1,000 acres of fallow land. The RTWF system had a total of $3,688 less labor, fuel, and repair costs, but required $4,002 more chemicals than the CVWF system. Variable costs were higher in the reduced tillage system but net returns also were higher because of greater yields than in the conventional tillage system. Depreciation, interest, and fertilizer costs were the same in conventional and reduced tillage wheat-fallow systems. This occurs because the same equipment is owned for producing these crops and the nitrogen fertilizer application rate is held constant.

Conventional wheat-fallow (CVWF) is the predominant cropping system on the Great Plains, but results in this study show average annual returns of -$10,085. Conventional wheat-sorghum-fallow (CVWSF) produced an average return to management of -$6,717. These results are mainly due to lower yields of the two systems compared to their reduced tillage counterparts.

The continuous sorghum (CVSS) and continuous wheat (CVWW) cropping systems produce a crop on all 2,000 acres annually and require large yearly inputs. These large expenses combined with comparatively lower yields produced annual returns of -$5,962 for continuous sorghum, and -$49,184 for the continuous wheat system.

Risk Measurement

Anderson and Ikerd (1984) report that agricultural procedures face two basic types of risks: business risks and financial risks.

Financial risk may be defined as the chance of loss or adverse outcome attributable to debt financing. Financial risk relates to not being able to meet debt service commitments and the resulting loss in equity. Risk management decisions must consider both business and financial risks (Anderson and Ikerd 1984).

Business risks represent the chance of loss resulting from unfavorable production and/or unfavorable market prices. They originate largely from yield and price variability, which affects net returns. Yield variability may be due to weather cycles, insect and disease problems, etc. Price variability comes from economic supply and demand factors largely beyond the farm manager's control.

To examine risk, this report compares yield, price, and net return variability with the use of standard deviation and coefficient of variation statistics.

A manager who must select from two or more alternatives needs to know the expected average return from each alternative. In addition, the variability or chance of the possible outcomes around the average or mean (expected) value is also important. A common statistical measure of variability is the standard deviation. In this study, it is calculated from the random yields produced on the Tribune fields over the period 1973-1983. A larger standard deviation indicates a greater variability of possible outcomes and, therefore, a greater probability that the actual outcome will be further from the mean or expected value. For example, wheat yields that range from 30 to 35 bu/acre, averaging 32.5 bu/acre every year, would have a lower standard deviation than wheat yields that average 32.5 bu/acre but range from 20 to 45 bu/acre.

Table 13. Annual Acres and Field Operations by Cropping System

	CROPPING SYSTEM[1]				
ITEM	RTWF	CVWF	RTWSF	CVWSF	CTSF
ANNUAL ACRES					
Wheat	1,000	1,000	666.6	666.6	—
Sorghum	—	—	666.6	666.6	1,000
Fallow	1,000	1,000	666.6	666.6	1,000
CROP ACRES	1,000	1,000	1,333.3	1,333.3	1,000
OPERATION[2]					
Tillage					
Wheat	4.0	6.5	4.0	6.5	—
Sorghum	—	—	2.0	3.5	7.5
Planting					
Wheat	1.0	1.0	1.0	1.0	—
Sorghum	—	—	1.0	1.0	1.0
SUB-TOTAL	5.0	7.5	8.0	12.0	8.5
Fertilizer[3]					
Wheat	1.0	1.0	1.0	1.0	—
Sorghum	—	—	1.0	1.0	1.0
Chemical[3]					
Wheat	1.0	—	1.0	—	—
Sorghum	—	—	0.6	0.6	1.66
Harvest[3]					
Wheat	1.0	1.0	1.0	1.0	—
Sorghum	—	—	1.0	1.0	1.0
TOTAL	8.0	9.5	13.6	16.6	12.16
ACRES COVERED[4]	8,000	9,500	9,060	11,115	12,166

[1] RTWF: Reduced Tillage Wheat-Fallow
CVWF: Conventional Tillage Wheat-Fallow
RTWSF: Reduced Tillage Wheat-Sorghum-Fallow
CVWSF: Conventional Tillage Wheat-Sorghum-Fallow
CTSF: Conservation Tillage Sorghum-Fallow

[2] Based on the average trips over field from Tribune test plots.

[3] Operations custom hired.

[4] Refers to total number of acres covered with all field operations per year.

Table 14. Yields, Income, and Returns by Cropping System

ITEM	CROPPING SYSTEM[1] RTWF	CVWF	RTWSF	CVWSF	CTSF	CVSS	CVWW
YIELDS,[2] Bu/A							
Wheat	38.22	31.34	36.92	30.37	—	—	15.81
Sorghum	—	—	52.98	40.16	64.61	38.74	—
INCOME & COSTS[3]							
Gross Income	$125,744	103,109	162,565	128,457	149,249	179,025	104,030
Variable Costs	$ 49,475	47,129	61,544	58,745	61,810	89,225	68,424
Fixed Costs							
(Owned Land)	$ 26,860	26,860	28,471	28,471	27,296	31,113	33,033
(Rented Land)	$ 44,255	39,205	55,364	47,958	50,372	64,649	51,757
Total Costs	$120,590	113,194	145,379	135,174	139,478	184,987	153,214
NET RETURNS	5,154	-10,085	17,186	-6,717	9,771	-5,962	-49,184
Landlord Inc.[4] (Rent Ac.)	$ 24,343	20,448	31,770	25,449	28,980	33,901	19,993

[1] RTWF: Reduced Tillage Wheat-Fallow
CVWF: Conventional Tillage Wheat-Fallow
RTWSF: Reduced Tillage Wheat-Sorghum-Fallow
CVWSF: Conventional Tillage Wheat-Sorghum-Fallow
CTSF: Conservation Tillage Sorghum-Fallow
CVSS: Conventional Tillage Sorghum-Sorghum
CVWW: Conventional Tillage Wheat-Wheat
[2] Data from the Tribune, KS Experiment Station.
[3] Based on mean 11-year yields & prices with 1984 cost estimates.
[4] Based on landlord receiving 1/3 of crop and paying 1/3 of yield increasing inputs. Represents income over variable costs.

Table 15. Returns and Selected Costs by Cropping System

RETURNS AND COSTS	CROPPING SYSTEM[1] RTWF	CVWF	RTWSF	CVWSF	CTSF	CVSS	CVWW
NET RETURNS	$ 5,154	-10,085	17,186	-6,717	9,771	-5,962	-49,184
COSTS:							
Labor Cost	$ 1,597	2,336	2,125	2,991	3,935	5,084	2,704
Fuel/Oil Cost	$ 3,421	5,260	3,621	5,573	5,237	6,656	5,316
Fertilizer Cost[2]	$ 8,646	8,646	9,425	9,425	8,646	10,982	10,982
Chemical Cost[2]	$ 4,002	—	4,718	1,662	7,587	9,674	—
Repair Cost	$ 3,770	4,880	4,373	5,440	4,450	7,440	6,320
Machinery Depreciation	$10,590	10,590	12,813	12,813	11,120	15,980	18,620
Machinery Interest	$12,340	12,340	14,627	14,627	13,000	18,840	21,600

[1] RTWF: Reduced Tillage Wheat-Fallow
CVWF: Conventional Tillage Wheat-Fallow
RTWSF: Reduced Tillage Wheat-Sorghum-Fallow
CVWSF: Conventional Tillage Wheat-Sorghum-Fallow
CTSF: Conservation Tillage Sorghum-Fallow
CVSS: Conventional Tillage Sorghum-Sorghum
CVWW: Conventional Tillage Wheat-Wheat
[2] Cost incurred by owner/operator.

Standard deviations are difficult to compare with each other when the probability distributions have different means or expected values. Probability distributions with higher expected values might have greater variability and often do (Kay, 1981). An important consideration in this situation is the relative variability. Does the probability distribution with the higher expected value really have greater variability relative to its larger expected value? To answer this question, the coefficient of variation is used.

The coefficient of variation measures variability relative to the expected value or mean of the probability distribution. This measure of variation is found by dividing the standard deviation by the mean and multiplying by 100. It provides a method of assessing the relative variability of different probability distributions that have different expected values. Small coefficients of variation show that the distribution has less variability in relation to its expected value. For example, if wheat yields 32.5 bu/acre and has a standard deviation of 6 bu/acre, the coefficient of variation would indicate that the relative variability is lower for sorghum with a yield of 60 bu/acre and a standard deviation of 10. The wheat coefficient of variation (CV) is (6/32.5) × 100 = 18.46. The sorghum coefficient of variation (CV) is (10/60) × 100 = 16.67. Therefore, in this example the wheat CV is slightly higher and indicates more variability than the sorghum CV.

Yield Variability Analysis

Table 16 contains the results of the variability analysis. The reduced tillage wheat-fallow (RTWF) system produced the highest average (mean) wheat yield of 38.22 bu/acre, 6.88 bu/acre more than the 31.34 average in the conventional wheat-fallow (CVWF) system. Wheat yields in the reduced tillage wheat-sorghum-fallow (RTWSF) system were 6.55 bushels per acre higher when compared to conventional tillage wheat-sorghum-fallow (CVWSF). Grain sorghum production was also higher in the reduced tillage wheat-sorghum-fallow system (RTWSF) in comparison with its conventional counterpart (CVWSF). Sorghum yields averaged 52.98 bu/acre in RTWSF and 40.16 bu/acre in the CVWSF system, a difference of 12.82 bu/acre.

In addition to increased yields, the reduced tillage systems generally had lower variability of yields than the conventional systems. The RTWF system had the lowest coefficient of variation, 30.60, compared with 39.80 for the CVWF system. The RTWSF also had a lower coefficient of variation than the CVWSF system. Of the systems including grain sorghum, conservation tillage sorghum-fallow (CTSF) has the lowest coefficient of variation of 43.07, followed by RTWSF with 47.08 (Table 16).

Price Variability Analysis

Table 16 also contains the results of the price variability analysis. The mean price of wheat over the 11-year period (1973-1984) was $3.29/bu, with the sorghum price on the average being $.98/bu lower at $2.31/bu. A comparison of these prices reveals that the sorghum price has a slightly higher variability as measured by the coefficient of variation. The coefficient of variation for sorghum is 17.90 versus 16.61 for wheat.

Net Return Variability Analysis

The reduced tillage wheat-fallow system (RTWF) has the lowest standard deviation of net returns, but only the third highest net return (Table 16). The conservation tillage sorghum-fallow system (CTSF) generates the second highest net return, but has the largest standard deviation. Reduced tillage wheat-sorghum-fallow (RTWSF) produces the largest net returns to management, but has the second highest standard deviation.

The coefficient of variation, which considers the size of the standard deviation relative to the size of the mean, is also reported to indicate a measure of risk (Table 16). Risk per dollar of expected return is lowest for the reduced tillage wheat-sorghum-fallow system (RTWSF). By using this measure, the higher expected returns outweigh the higher standard deviation of return associated with it. This result is interesting to compare with the coefficient for the reduced tillage wheat-fallow system (RTWF). Although this system had the lowest standard deviation of return, its expected return was enough lower than the reduced tillage wheat-sorghum-fallow system (RTWSF) to indicate a higher risk per dollar of expected return. The conservation tillage sorghum-fallow system (CTSF) had the highest coefficient of variation among the reduced tillage systems.

Table 17 contains a listing of annual net returns by cropping system over the period 1973-1983. Results reveal that the reduced tillage systems produce fewer years of negative returns when compared to their conventional counterparts. For example, the reduced tillage wheat-sorghum-fallow (RTWSF) system has negative returns only 3 of 11 years, versus 5 years in CVWF. The RTWF system has negative returns 4 out of 11 years, whereas CVWF produced negative returns in 5 of 11 years. The conservation tillage sorghum-fallow (CTSF) and conventional wheat-sorghum-fallow (CVWSF) incur the largest total negative returns to management (the sum of all negative returns over 11 years). Reduced tillage wheat-sorghum-fallow (RTWSF) and reduced tillage wheat-fallow (RTWF) have total negative returns of-$189,959, and -$160,987, respectively. The reduced tillage wheat-fallow system had the smallest total losses for the 11-year period. If the decision maker's objective is to minimize loss, then this system may be the most desirable. If risk or income variability is not a concern to the decision maker, then the reduced tillage wheat-sorghum-fallow system would be preferred because it has the highest average net return.

Table 16. Yield, Price, and Net Return Variability Analysis by Cropping System

VARIABILITY	CROPPING SYSTEM[1] RTWF	CVWF	RTWSF	CVWSF	CTSF
YIELD (Bu/Acre) VARIABILITY					
Wheat Mean	38.22	31.34	36.92	30.37	—
Std. Deviation	11.69	12.47	13.57	10.73	—
Coeff. Variation	30.60	39.80	36.76	35.33	—
Sorghum Mean	—	—	52.98	40.16	64.61
Std. Deviation	—	—	24.94	27.01	27.82
Coeff. Variation	—	—	47.08	67.26	43.07
NET RETURN INCOME VARIABILITY					
Mean Net Returns[2]	$ 6,794	$-8,185	$17,301	$-4,178	$ 9,676
Std. Dev. Returns	$43,911	$46,134	$62,683	$53,477	$72,669
Coeff. Variation[3]	6.46	—	3.62	—	7.50
PRICE VARIABILITY ($/Bu)	Wheat	Sorghum			
Mean	$ 3.29	$ 2.31			
Std. Deviation	.546	.414			
Coeff. Variation	16.61	17.90			

[1] RTWF: Reduced Tillage Wheat-Fallow
CVWF: Conventional Tillage Wheat-Fallow
RTWSF: Reduced Tillage Wheat-Sorghum-Fallow
CVWSF: Conventional Tillage Wheat-Sorghum-Fallow
CTSF: Conservation Tillage Sorghum-Fallow
[2] Based on 11 years yields & prices. Net return to management.
[3] Indicates a simple measure of risk. Lowest positive number indicates the least risk per dollar of expected return.

Table 17. Yearly Net Returns per Cropping System

YEAR[2]	CROPPING SYSTEM[1] RTWF	CVWF	RTWSF	CVWSF	CTSF
1973	$ 2,141	1,440	30,109	1,546	11,346
1974	$ 32,173	16,517	6,173	-17,396	-93,724
1975	$ 47,511	7,337	33,960	10,671	-16,677
1976	$ -59,415	-80,416	-107,638	-99,860	-99,872
1977	$ -52,882	-46,138	-55,582	-63,135	-44,529
1978	$ 14,323	-29,280	48,894	16,310	16,170
1979	$ 38,838	11,101	3,638	-52,024	-1,802
1980	$ -47,056	-61,239	-26,739	22,122	43,318
1981	$ 26,277	8,293	102,658	76,891	92,673
1982	$ -1,634	-8,360	68,314	-11,186	131,804
1983	$ 74,467	90,706	86,527	70,099	67,735
MEAN RETURN	$ 6,794	-8,185	17,301	-4,178	9,676
TOTAL NEGATIVE	$-160,987	-225,433	-189,959	-243,601	-256,604
YEARS NEG.	4	5	3	5	5

[1] RTWF: Reduced Tillage Wheat-Fallow
CVWF: Conventional Tillage Wheat-Fallow
RTWSF: Reduced Tillage Wheat-Sorghum-Fallow
CVWSF: Conventional Tillage Wheat-Sorghum-Fallow
CTSF: Conservation Tillage Sorghum-Fallow
[2] Based on annual yield and season average price and 1984 cost of production estimates.

Cash Flow Requirements of Selected Systems

A computer program entitled Kansas Financial Analysis and Resource Management, <K-FARM>, was used to analyze the cash flow of the different systems (Barnaby, 1984). The systems studied were conventional tillage wheat-fallow (CVWF), reduced tillage wheat-fallow (RTWF), reduced tillage wheat-sorghum-fallow (RTWSF), and conservation tillage sorghum-fallow (CTSF). Cash flow assumptions are listed below.

1. The cash flow analysis was conducted for all crop and fallow combinations on a calendar year basis with cash entries being recorded by month.
2. Annual payments on the 4WD and 2WD tractors occur in October. The equipment is financed over 5 years at 15 percent interest. The principle payment is $20,681 and the interest payment is $15,512 per year.
3. The analysis includes a land payment for 158 acres purchased in 1977 at $400/acre. This payment is amortized over 25 years at 12 percent interest. The annual principle payment is $948 and the interest payment is $7,212. Both payments for the land are made in April.
4. Annual real estate taxes of 2.00/acre are paid during June and December.
5. A sorghum planter is added to the systems containing sorghum. The planter is financed over 5 years at 15 percent interest. The principle payment is $5,426 and the interest payment is $4,070. Both payments for the planter are made in November.
6. Average family living expenses of $1,500 per month are included in the analysis.
7. Cash inflows based on annual average prices occur in July for wheat and October for grain sorghum.

At the beginning of the analysis, each cropping system has a zero operating balance on January 1. The reduced tillage wheat-sorghum-fallow (RTWSF) received the largest cash inflow, grossing $126,833 after share rent was paid to the landlord. This was followed by $116,396 for conservation tillage sorghum-fallow (CTSF), with $98,065 for reduced tillage wheat fallow (RTWF), and $80,410 for conventional wheat-fallow (CVWF). Conservation tillage sorghum-fallow (CTSF) required the largest interest payment of $3,812, followed by conventional tillage wheat-fallow (CVWF) with $2,160 (Table 18). The reduced tillage wheat-sorghum-fallow (RTWSF) required $1,782, followed by reduced tillage wheat-fallow (RTWF) with $1,750.

The conservation tillage sorghum-fallow system (CTSF) required the largest operating balance during the year, $56,070 (Table 18). This is due to somewhat greater costs and the delayed cash inflow from sorghum harvest, which is 3 months after all of the other systems have reduced the operating balance as a result of wheat harvest income. The required total operating balances for the remaining three systems were within $675 of each other. The reduced tillage wheat-fallow system (RTWF) required total credit of $50,464, conventional tillage wheat-fallow (CVWF) used $50,374, and $49,789 was needed in the reduced tillage wheat-sorghum-fallow system (RTWSF) to cover financing needs. These results show that there is generally no significant additional need for larger credit lines in the reduced tillage systems.

Table 18. Cash Flow Requirements and Interest Costs[1]

SYSTEM[2]	MAXIMUM CASH NEED	INTEREST COST
CTSF	$56,770	$3,812
CVWF	$50,374	$2,160
RTWSF	$49,789	$1,782
RTWF	$50,464	$1,750

[1] Based on crop plus fallow expenses over a 12-month period.
[2] CTSF: Conservation Tillage Sorghum-Fallow
CVWF: Conventional Tillage Wheat-Fallow
RTWSF: Reduced Tillage Wheat-Sorghum-Fallow
RTWF: Reduced Tillage Wheat-Fallow

SUMMARY AND CONCLUSIONS

Enterprise budget analysis reveals that the reduced tillage systems have higher net returns to management, mainly because of increased yields compared to the conventional systems. Systems including sorghum produce higher returns, but also show greater variability of returns when compared to wheat-only systems. Thus, variability as well as average returns should be considered.

When consideration is given to variability of returns, the reduced tillage wheat-fallow system (RTWF) has the lowest potential variability of return as measured by the standard deviation. However, when the coefficient of variation, indicating variation per dollar of expected return, is considered, the reduced tillage wheat-sorghum-fallow (RTWSF) has the lowest amount of risk per dollar of expected return. Using this method, the higher expected return of the reduced tillage wheat-sorghum-fallow system outweighs the increased return variability associated with it, when compared to the reduced tillage wheat-fallow system.

Given these findings, the optional management strategy in western Kansas may be to employ reduced tillage methods as an alternative to conventional methods. However, it is difficult to select which reduced tillage system is best for an individual decision maker.

Farmers who are risk adverse would likely prefer the reduced tillage wheat-fallow system (RTWF), because it incurs fewer losses. Those who are neutral to risk would likely prefer the reduced tillage wheat-sorghum-fallow system (RTWSF), because it generates the highest average net return.

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