Economics of Reduced-Till, No-Till and Opportunity Cropping in Western Kansas

By Robert O. Burton, Jr., Ray P. Smith and Alan J. Schlegel

Abstract

Reduced-till (RT) is compared to no-till (NT) on a western Kansas farm using elevated crop residue levels and higher intensity opportunity cropping. Per acre expenses, net revenue and risk are determined with and without opportunity cropping. NT opportunity cropping is more profitable than RT eco-fallow using corn; however, risks and expenses are greater. Higher intensity NT cropping, with intensity decreased when soil moisture at planting is inadequate, increased net revenue and risk.

The benefits of no-till farming and the decrease in the cost of glyphosate herbicide have increased no-till popularity. Glyphosate herbicide is popular because of its ability to kill a large spectrum of weeds and its relative safety. The glyphosate warning labels carry the lowest level assigned by the Environmental Protection Agency. No-till tends to increase yields with time and provides higher yields when moisture is limited (Schlegel, Dumler and Thompson). No-till protects the soil from wind and water erosion. This study compares the economics of reduced-till (RT) to no-till (NT) in western Kansas using elevated crop residue levels and higher intensity opportunity cropping strategies to overcome obstacles. Before presenting procedures and data, several issues related to farming in western Kansas that affected the choice of cropping systems, analytical procedures and results are discussed.

Three obstacles limit adoption of NT in western Kansas. First, some native perennial grasses are resistant to herbicides. Second, dryness in September can result in a soil crust forming that seeding equipment will not penetrate for fall planting and/or drying of the soil below the seeding depth of no-till drills. Third, current NT seeding technology runs over residue, breaking it off at ground level. This crop residue decomposes quickly and is removed by rain and wind, exposing soils to erosion.

Currently, eco-fallow with reduced-till is a popular farming method. Eco-fallow is a crop rotation that lasts for three years. The first year the land is summer fallowed and wheat is planted in the fall. Wheat is harvested in mid-summer of the second year. A summer crop, such as corn, grain sorghum or sunflower is planted in May or June and harvested in the fall of the third year.

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This manuscript is Kansas Agricultural Experiment Station Contribution number 08-228-J.

Tillage is used to increase the chances that moisture will be available to germinate wheat in the fall. Tillage kills the weeds including native perennial grasses and provides a compacted layer to seal in subsoil moisture in case rains are not received in September. When wheat is planted, a grain drill equipped with a hoe opener (commonly called a "hoe drill") is used. A "hoe opener" as described by the American Society of Agricultural Engineers is, "A shank-mounted, narrow, vertical or forward-curved tool with a pointed or rounded leading edge" (p. 366). Because moisture is deeper in the soil in dryer climates, a hoe drill provides a deeper furrow in the soil. The hoe drill moves several inches of soil, placing the seed into the compacted layer subsoil moisture and leaves the soil in ridges that helps protect against wind erosion in the spring.

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

Crop residue protects the soil from wind erosion and helps maintain soil moisture for spring-planted crops. Cold temperatures during winter cool the soil, which allows seedbeds to retain winter and spring moisture for longer periods of time. These wetter seedbeds are available in early May, before temperatures rise and dry top soils in late May and early June. Any standing residue protects the soil from wind erosion and consequently extends the time the ground is cool and wet, decreasing reliance on rain to provide moisture for seed beds.

NT farming uses methods other than tillage, such as sanitation, competition and rotations to control weeds. Sanitation requires keeping weed seeds out of the seedbed. NT farmers must prevent the weeds from producing seed and use low soil disturbance planters that do not incorporate the weed seed into the soil. Because NT can increase water efficiency, farmers utilize higher water-use crop rotations to provide competition for the weeds. Grain sorghum is a higher water use crop and produces superior residue compared to corn. Grain Sorghum can be planted after corn in an eco-fallow rotation resulting in a four year rotation and increased residue levels during the fallow period. Rotation of crops allows using different herbicides while the crop is growing and fallow during different times of the year when weeds can be easily and cheaply controlled. Higher seeding rates in narrow rows may provide crop canopies that shade weeds from sunlight. Crop residues also provide shading. The goal of narrow row spacing is for the crop to quickly canopy; however, narrow row spacing destroys more crop residue than wide row spacing.

Low Residue Disturbance Seeding

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

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

Native perennial grasses can be controlled by using three agronomic strategies. First grain sorghum will be planted in 15-inch rows to canopy and shade native perennial grasses. Grain sorghum provides excellent canopy and leaves large amounts of standing residue. Corn does not control native perennial grasses as well as grain sorghum because it is usually planted in 30-inch rows at low seeding rates. Most corn headers used for harvesting require 30-inch rows. Second, additional cash crops are used to control native perennial grasses. More intensive cropping, with less fallow time and more opportunity cropping, decreases moisture availability to perennial grasses. Third, recommended rates of glyphosate herbicide applied at appropriate times are used to better control perennial grasses than lower rates used to reduce costs.

This system is not a controlled traffic system because the majority of the traffic will not follow the same path in the field every year. Hagney states that with controlled traffic, heavy traffic areas lose water infiltration and erode during heavy rainfall.

Increased residue levels should protect the soil from the sun and wind during the summer fallow period and increase the chances of having adequate soil moisture in the seedbed when seeding wheat in the fall. Currently, using NT, the authors believe that sometimes as little as three tenths of an inch of rainfall in the month of September will allow seeding. However, some years, even this amount will not be received and wheat stands will be poor. When moisture for adequate seedbeds is not available, fields may have to remain fallow until the next spring.

Opportunity Cropping

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

Location of Research

The farm used in this study is located in Greeley County, Kansas on the Kansas-Colorado border. The Kansas State University Southwest Research-Extension Center, Tribune Unit is located in Greeley County and is the major source for weather and yield data. The climate in Greely County, Kansas is semi-arid. Rainfall data from the Southwest Research-Extension Center, Tribune Unit indicate that the average annual rainfall from 1996 through 2005 was 18.51 inches. During this time period, rainfall was variable, ranging from an annual low of 10.01 inches to an annual high of 26.21 inches. These data were obtained from Alan Schlegel, the agronomist-in-charge of the Tribune Unit. The yields are a compilation of several different RT and NT studies performed at the Tribune Center.

Literature Review

Literature that supports NT farming addresses the following five issues: economic support for more intensive cropping (Smith and Young; Dhuyvetter et al.; Schlegel, Dumler and Thompson; Schlegel et al., 2005; Farahani and Peterson; Stone and Schlegel; and Dhuyvetter and Kastens), importance of wheat in NT (Schlegel et al., 1999; Lyon et al.), the yield benefits of crop residue (Power et al.; Power, Whilhelm and Doran), support for crop sequencing, (Anderson) and dry land water management (Lyon and Stone; and Westfall).

Objective

The objective of this study is to compare per acre expenses, net revenue, and the risks of high cropping intensity NT with RT eco-fallow with and without opportunity cropping. The goal is to find the optimum rotation so a combination of rotations will not be considered. At the same level of net revenue per acre, NT farming will be chosen to replace RT because of the improved erosion control. Table 1 shows the cropping systems to be compared.

This study started with the desire to compare the profitability of the following two cropping systems in western Kansas: eco-fallow (a consistent rotation of wheat/corn/summer fallow with reduced tillage) with a NT system that takes advantage of opportunity cropping. Two issues that affect the profitability of the two systems are: (1) NT versus RT; and (2) opportunity cropping versus no opportunity cropping. Because the authors wished to determine the extent to which differences between the two systems were caused by either tillage or opportunity cropping, the following four systems were analyzed: (1) consistent reduced-till rotation with wheat/corn/summer fallow, called "RT rotation" in this study; (2) consistent no-till rotation with wheat/corn/grain sorghum/summer fallow, called "NT rotation" in this study; (3) opportunity cropping with wheat, corn, grain sorghum and tilled fallow, called "RT opportunity cropping" in this study; and (4) opportunity cropping with wheat, corn, grain sorghum and NT fallow, called "NT opportunity cropping" in this study. The slash (/) between the crops and fallow in the RT rotation and NT rotation indicate that the crops were consistently planted and the land fallowed in a three-year sequence for the RT rotation and a four-year sequence for the NT rotation. The comma (,) between crops and fallow in the RT opportunity and NT opportunity cropping systems indicate that the four-year sequence of wheat, corn, grain sorghum and fallow could be interrupted by opportunity cropping.

In this study, a cropping system is identified as a "reduced-till" system when tillage is used only during summer fallow to control weeds. A cropping system is identified as a "no-till" system when tillage is not used. Opportunity cropping means that the cropping system would be interrupted if adequate rainfall allows planting of a potentially more profitable crop or if inadequate rainfall indicates that more fallow is needed.

Procedures and Data

Crop enterprise budgets are used to determine cost of production, net revenue and risk for each cropping system and for each crop in each system. The study uses the 10 years of NT yield data available from the Southwest Research-Extension Center, Tribune Unit. For the RT rotation the beginning farm is 1/3 wheat, 1/3 corn, and 1/3 RT fallow (a 3-year rotation). The opportunity cropping RT and both NT cropping systems will have four beginning equal sized fields of wheat, corn, grain sorghum and summer fallow (4-year rotations). The costs of production and net revenue for each cropping system are compared by calculating a per acre average.

Net revenue is also calculated for each crop in each system. Summer fallow expenses are charged to the following crop. This article is focused on determining the most economical system and not the most profitable crop. A single crop or fallow by itself may show little or no profitability; but if it improves the profitability of the rotation, it should be included in the rotation.

Net Revenue

Revenues and costs include only those that are affected by the change in farming practice. Direct and counter-cyclical payments, land costs and management costs are not included. If fields do not produce enough revenue to cover the cost of harvest, there is no harvest expense and no grain income in these years.

The yield data and the price data are historical annual yields and prices. Crop prices are from Kansas Agricultural Statistics West Central District (USDA, 2007). The price is the average of the monthly prices for the first six months after harvest. Yields for RT and NT wheat after summer fallow, corn and grain sorghum after corn and rainfall data are from the Southwest Research-Extension Center, Tribune Unit (Table 2). Because yield data comparing RT to NT corn are not available for western Kansas, some data were estimated. Dhuyvetter and Kastens estimate that NT corn yields 15 percent more than RT corn. Schlegel, Dumler and Thompson showed that NT grain sorghum yields 23 percent more than RT grain sorghum. If yield data are not available, yields are estimated using water use efficiency data and Stone and Schlegel's water use equations. Based on the authors' knowledge and experience, grain sorghum yields after fallow should be higher than grain sorghum yields after wheat. Therefore, when fallow grain sorghum estimated yields produced yields lower than grain sorghum after wheat, the grain sorghum yields after wheat were from the Southwest Research-Extension Center, Tribune Unit.

The yield data are also used as rate yields for indemnity payments. Crop Revenue Coverage (CRC) crop insurance indemnity payments are received whenever revenue falls below the CRC guarantee. Crop insurance indemnity payments are equal to the actual yield times the harvest price subtracted from the greater of the harvest price or planting price times the guarantee. Insurance planting prices and harvest prices are obtained from agmanager.com (Barnaby 2004a, 2004b and 2004c). Insurance rates are determined by the rate yield. The insurance premium is determined using the U.S. Department of Agriculture RMA premium calculator available on the Internet (USDA 2006). Loan Deficiency Payments (LDPs) are not estimated because, at the time this study was completed, the authors were aware that they are trade distorting and, therefore, might not be in the next farm bill (Wiesemeyer). LDPs are available in the 2008 Farm Bill. However, producers may elect not to receive LDPs in order to receive other benefits.

Cost of Production

Costs of production are current actual costs from the study farm. All machinery work is custom hired and costs are custom rates paid by the farm. If producers need to purchase NT machinery to incorporate NT production systems, then fixed and variable costs of the NT machinery relative to costs of machinery used without NT would need to be considered. For the RT systems tillage is used only during summer fallow to control weeds. For the NT systems tillage is not used. Based on field records from the case farm, in this study, for the RT fallow period we used one spray operation and 2.9 tillage operations. For the NT fallow period we used 3.5 spray operations.

Risk

In this study, risk is defined as the number of annual losses during the 10-year study period and the average of the three lowest income years out of 10 for each cropping system. These risk measures consider that farmers are not adverse to higher income years. The goal is to compare risk between the systems; therefore fixed costs and fixed incomes are not considered. The term "net revenue" in this paper will mean gross revenue minus variable costs. A loss will be defined as the failure to recover variable costs meaning that the annual average net revenue of all crops in a cropping system is less than zero.

Guidelines for Opportunity Cropping

Rainfall before planting and the previous crop were used to select opportunity crops in the systems that used opportunity cropping. Additional details are available in Smith. The base rotation for opportunity cropping is wheat, corn, grain sorghum and fallow. Grain sorghum follows corn because it is more drought resistant and is able to use water that corn does not. Corn does not usually yield well behind grain sorghum; but if there is little grain sorghum produced followed by a wet winter, corn following grain sorghum can yield well. Corn only follows poor crops of grain sorghum because of the lower grain sorghum residue production. About six to eight inches of precipitation will be needed before a crop is planted, less when planting wheat in the fall. This moisture will help to keep the plant growing until flowering. Eight inches will provide roughly two feet of wet soil. This assumes that fallow efficiency is near 50 percent because of dry soils after harvest and soil water holding capacity is 2 to 4 inches per foot (Soil Survey Staff). Following these guidelines resulted in the crop sequences shown in Table 3.

Results

Table 4 summarizes the results in terms of cost of production, net revenue and risk. All three of these criteria for evaluating the cropping systems were affected by crop intensity. Crop intensity is measured by the percent of each rotation that is used to produce cash crops. The RT rotation is by definition 66.7 percent crops and 33.3 percent fallows (20 crops out of 30 possible cropping periods). The NT rotation is by definition 75 percent crops and 25 percent fallows (30 crops out of 40 possible cropping periods). The cropping intensity of both opportunity-cropping systems is the same with 72.5 percent crops and 27.5 percent fallows (29 crops out of 40 possible cropping periods).

Cost of Production

Average variable crop expenses increase by 27 percent when switching from a RT rotation to the NT rotation. The RT opportunity cropping expenses are higher than the RT rotation by 17 percent; but lower than either NT system. NT opportunity cropping lowers variable crop expenses over the NT rotation by five percent.

Net Revenue

NT opportunity cropping with net revenue of $20.02 has the highest net revenue and shows $3.97 per acre more net revenue than the RT rotation (Figure 1). The NT rotation produces the lowest net revenue, $10.65. The RT opportunity cropping produces $3.83 less net revenue than the RT rotation; while NT opportunity cropping produces $9.37 more net revenue than the NT rotation. The NT rotation produces more gross income than the RT rotation, but it was not enough to overcome the greater per acre expense.

Wheat's net revenues are similar for all rotations (Figure 2). Corn is much more profitable when grown in an opportunity cropping rotation. For the cropping systems evaluated, grain sorghum on average does not cover variable costs. This appears to be largely due to lower indemnity payments in low yielding years. Grain sorghum's average indemnity payment was $21.90 per acre less than corn for the NT rotation for the 10-year period. Raising grain sorghum as an opportunity crop lowers the net revenue for grain sorghum.

Risk

During the 10-year study period, the RT rotation shows only one year in which variable costs were less than revenues (Figure 3). This was the least risky cropping system. The RT rotation's average of the worst three years was a positive $1.19 (Figure 4). RT opportunity cropping showed the most risk with four years of variable costs greater than revenues and the worst three-year average of variable costs greater than revenues of negative $11.96. The NT rotation and NT opportunity cropping both showed three years of losses. The NT rotation's worst three-year average was negative $4.73. The NT opportunity cropping system's worst three-year average was negative $5.50.

Interpretation

Switching from the RT rotation to other practices increased variable costs. The RT opportunity cropping system increased costs because grain sorghum was added. The NT rotations increased costs because of the use of more herbicides and more grain sorghum acres. Opportunity cropping increased net revenue variability. The increase in variable costs explains some of the increased risk of the NT rotation and the opportunity cropping systems.

The RT rotation has higher net revenue than either the NT rotation or the RT opportunity cropping. However, when NT and opportunity cropping are combined, (in the NT opportunity cropping system), net revenue increases above the RT rotation. By definition, the NT rotation does not adjust the crop rotation when subsoil moisture is inadequate resulting in a decrease in net revenue. Opportunity cropping increases the profitability of corn and the rotation by not planting when subsoil moisture is low, resulting in lower intensity. In addition, NT increases the net revenues of corn and grain sorghum because of NT yield increases. Thus, too much intensity can reduce net income.

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

NT has a crop insurance advantage over RT. The lower proven yield of grain sorghum causes the insurance rate of RT grain sorghum to be $0.20 per dollar of insurance; while the insurance rate for NT opportunity cropped grain sorghum is $0.12 per dollar of insurance. The average sign up guarantee is $90.54 per acre for NT opportunity cropped grain sorghum and is $71.72 per acre for RT grain sorghum.

Grain sorghum on average does not cover variable costs under any cropping system considered. This is due in part to higher insurance costs and lower indemnity payments compared to corn. It cost $0.20 to buy a dollar of insurance for RT grain sorghum. The same coverage costs about $0.11 for corn and $0.09 for wheat. The average sign up guarantee for RT grain sorghum was $71.72. The average sign up guarantee for RT corn was $97.00. Other costs that may cause grain sorghum to be less profitable are the phosphorus and zinc fertilizers at planting used to speed up maturity because of local weather and climate conditions and the use of glyphosate to desiccate the plant at harvest. This practice has been used on the case farm, but it is not widely used in the area.

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

Grain sorghum is not profitable as a crop, but this study is comparing rotations, not crops. Grain sorghum is necessary to increase residues and compete against perennial grasses. Long-term NT rotations are difficult to achieve without grain sorghum. Grain sorghum leaves a valuable residue, competes with perennial grasses and is an important part of the most profitable NT opportunity cropping system. As suggested by Lyon et al., increased cropping intensity lowers the yield of some crops, but the profitability of the cropping system is increased.

Results indicate that NT opportunity cropping has larger net revenues than the RT rotation. If the benefits of switching to NT outweigh the extra risk associated with the higher cost, then producers should switch to NT. The NT opportunity cropping system involves lower cropping intensity (not planting some fields) during dry times. NT farming increases net revenues, expenses and risk, and provides the major benefit of preserving soil.

Suggestions for Further Research

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

Conclusions

This analysis reveals that higher intensity NT cropping can increase net revenues as long as intensity is decreased when soil moisture at planting is not adequate; however, risks and expenses are greater. Results of this case study are directly applicable to the case farm and they indicate that for farms similar to the case farm, NT may be economically viable.

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Table 1. Cropping systems[a]

Tillage	Consistent Rotation	Opportunity Cropping
Reduced-till	Wheat/corn/summer fallow (RT rotation)	With wheat, corn, grain sorghum, and tilled fallow. (RT opportunity cropping)
No-Till	Wheat/corn/grain sorghum/summer fallow (NT rotation)	With wheat, corn, grain sorghum, and NT fallow. (NT opportunity cropping)

[a] The slash (/) between the crops and fallow in the RT rotation and NT rotation indicate that the crops were consistently planted and the land fallowed in a three-year sequence for the RT rotation and a four-year sequence for the NT rotation. The RT rotation is often called "eco-fallow." The comma (,) between crops and fallow in the RT opportunity and NT opportunity cropping systems indicate that the four-year sequence of wheat, corn, grain sorghum, and fallow could be interrupted by opportunity cropping. In this study, opportunity cropping means that the cropping system would be interrupted if adequate rainfall allowed planting of a potentially more profitable crop or if inadequate rainfall indicated that more fallow was needed.

Table 2. Yield data 1996-2005 (bushels per acre)

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

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

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

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

[a]These data were obtained from Alan Schlegel, the agronomist-in-charge of the Tribune Unit, Southwest Research-Extension Center of Kansas State University.

The yields are a compilation of several different reduced-till and no-till studies performed at the Tribune center.

[b]Denotes an estimated number. Based on Schlegel, Dumler, and Thompson, reduced-till grain sorghum yields are estimated to be 23% lower than no-till yields.

Based on Dhuyvetter and Kastens, no-till corn yields are estimated to be 15% higher than reduced-till yields.

[c]This yield was estimated using Stone and Schlegel's water use equation.

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

Table 3. Crops planted for opportunity cropping with RT and NT, 1996-2005[a]

Reduced-till Opportunity Cropping

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Field 1	Wheat	Corn	Gr. Sorg.	Fallow	Wheat	Corn	**Fallow**	Wheat	Corn	Gr.Sorg.
Field 2	Corn	**Fallow**	Wheat	Corn	Gr. Sorg.	Fallow	Wheat	Corn	Gr. Sorg.	Fallow
Field 3	Gr.Sorg.	Fallow	Wheat	Corn	Gr. Sorg.	Fallow	Wheat	Corn	Gr. Sorg.	Fallow
Field 4	Fallow	Wheat	Corn	Gr. Sorg.	Fallow	Wheat	**Fallow**	Wheat	Corn	Gr.Sorg.

No-till Opportunity Cropping

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Field 1	Wheat	Corn	Gr. Sorg.	Fallow	Wheat	Corn	**Fallow**	Wheat	Corn	**Wheat**
Field 2	Corn	**Fallow**	Wheat	Corn	Gr. Sorg.	Fallow	**Gr.Sorg.**	Fallow	Wheat	Corn
Field 3	Gr.Sorg.	Fallow	Wheat	Corn	Gr. Sorg.	Fallow	**Gr.Sorg.**	Fallow	Wheat	Corn
Field 4	Fallow	Wheat	Corn	Gr. Sorg.	Fallow	**Gr.Sorg.**	Fallow	Wheat	Corn	**Wheat**

[a] To analyze opportunity cropping, the crop sequence was started with four equal-sized fields of wheat, corn, grain sorghum (Gr. Sorg.), and summer fallow. Rainfall before planting and the previous crop were used to select each crop in the system. In this study, opportunity cropping means that the cropping system would be interrupted if adequate rainfall allowed planting of a potentially more profitable crop or if inadequate rainfall indicated that more fallow was needed. In this table, when the crop sequence was interrupted by opportunity cropping, the opportunity crop is bolded. On each field one crop was harvested or the field was fallowed each year. There was no double cropping. Additional details are available in Smith.

Table 4. Cropping intensity, net revenue and risk for four different cropping systems in western Kansas, 1996-2005

		10-Year Average				
Cropping System	Cropping Intensity[a]	Gross Revenue per Tillable Acre	Gross Expense per Tillable Acre	Net Revenue per Tillable Acre	Number of Years out of 10 with Losses	Average of 3 Worst Years
Reduced-Till Rotation	66.7%	$80.69	$64.64	$16.05	1	$1.19
No-Till Rotation	75.0%	$92.88	$82.24	$10.65	3	($4.73)
Reduced-Till Opportunity	72.5%	$88.03	$75.81	$12.22	4	($11.96)
No-Till Opportunity	72.5%	$98.47	$78.45	$20.02	3	($5.50)

[a] The reduced-till rotation is by definition 66.7% crops and 33.3% fallows (20 crops out of 30 possible cropping periods. The crop sequence was started with three equal-sized fields of wheat, corn, and summer fallow over a ten-year period. So there were 30 possible cropping periods in the analysis.) The no-till rotation is by definition 75% crops and 25% fallows (30 crops out of 40 possible cropping periods. The crop sequence was started with four equal-sized fields of wheat, corn, grain sorghum, and summer fallow over a ten-year period. So there were 40 possible cropping periods in the analysis.) The cropping intensity of both opportunity-cropping systems is the same with 72.5% crops and 27.5% fallows (29 crops out of 40 possible cropping periods. The crop sequence, for both opportunity cropping systems, was started with four equal-sized fields of wheat, corn, grain sorghum, and summer fallow over a ten-year period. So there were 40 possible cropping periods in the analysis.)

Figure 1. Ten-year average net revenue per acre

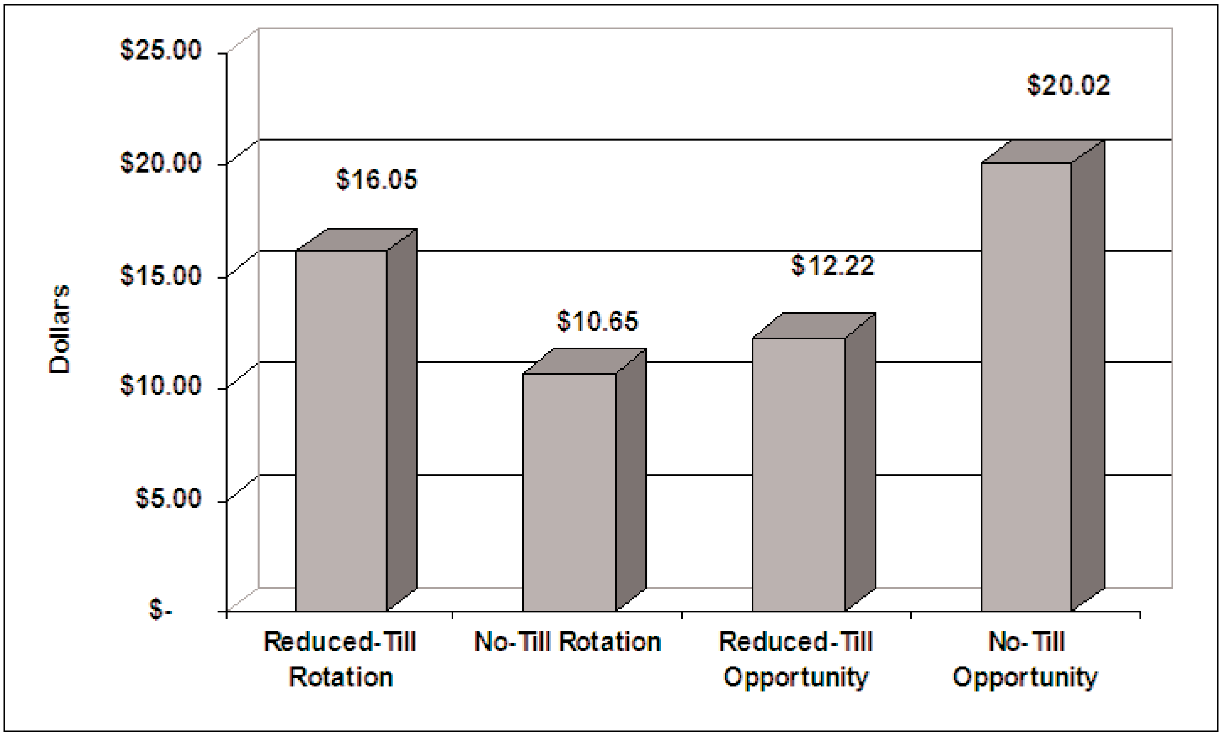

Figure 2. Ten-year average net revenue by crop

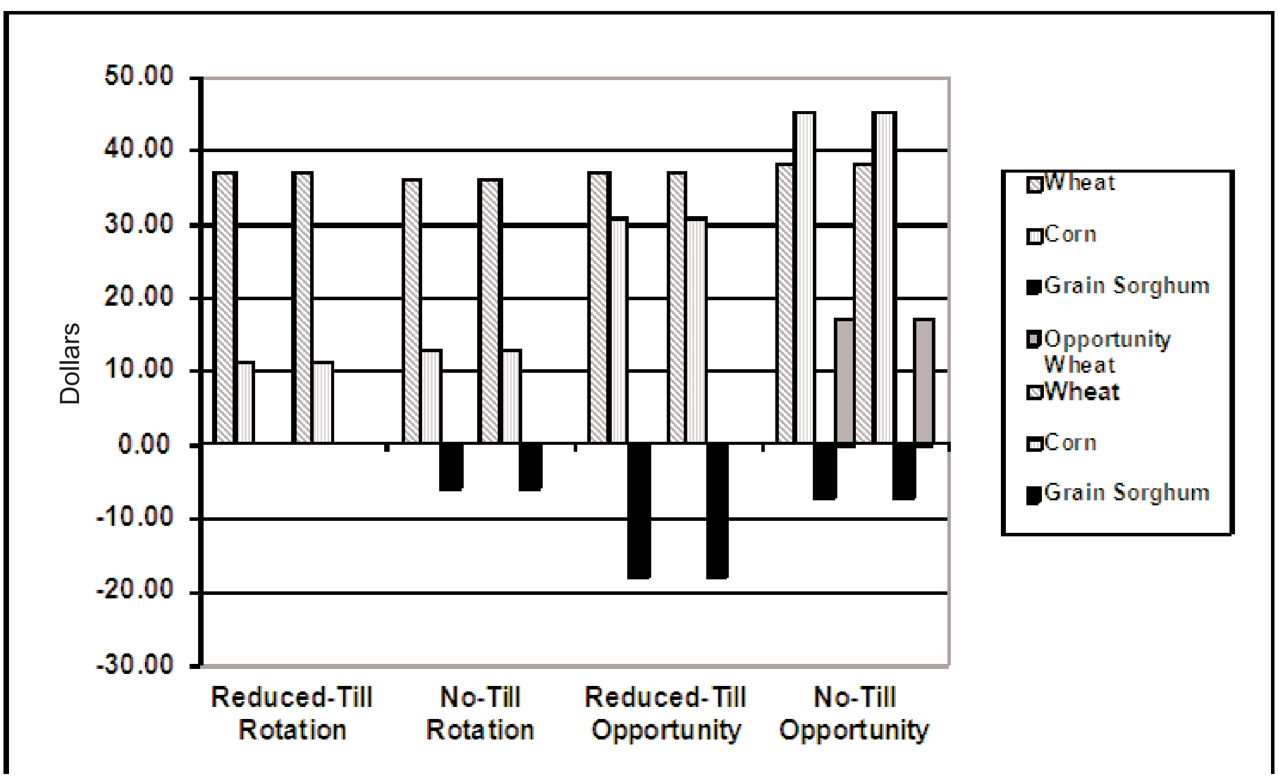

Figure 3. Number of years out of ten with a negative per acre net revenue by cropping system

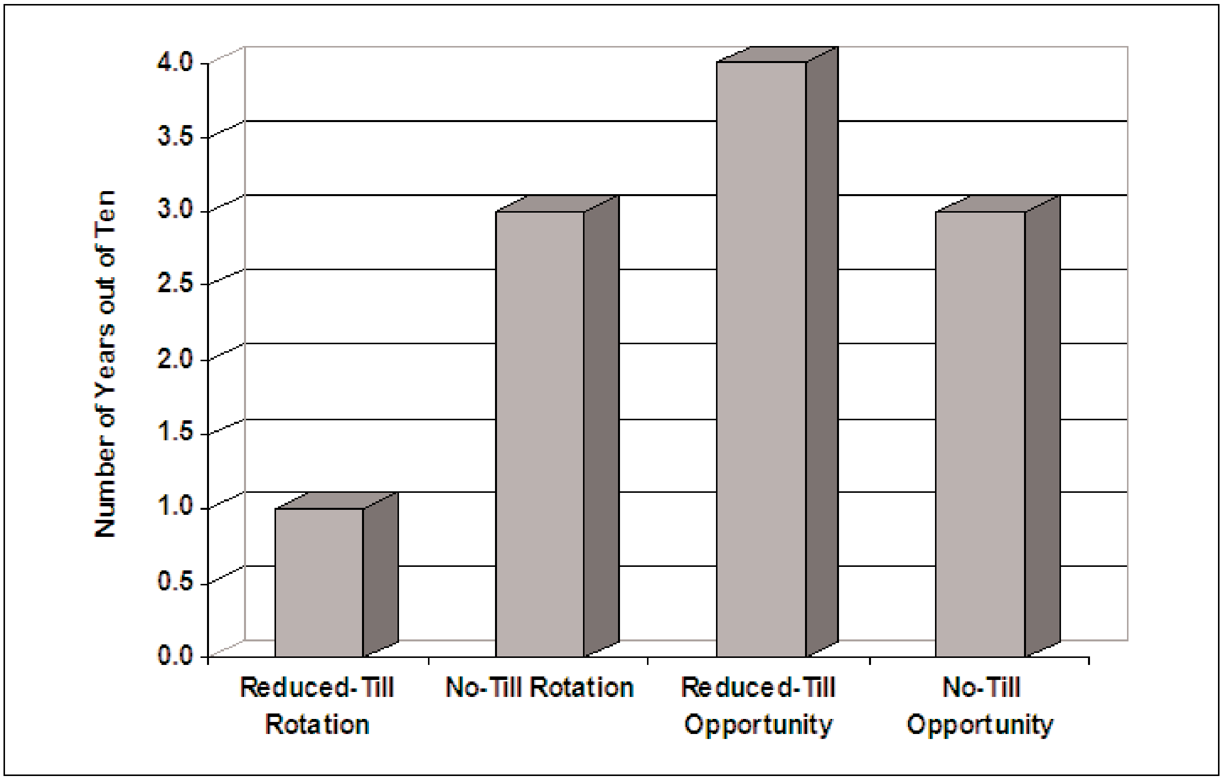

Figure 4. Averages of worst three years out of ten of per acre net revenue by cropping system