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Impact of Conservation Tillage Practices on Winter Wheat Production for Grazing Stocker Cattle

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Introduction

According to the National Agricultural Statistics Service, Arkansas averaged 900,000 acres of wheat grown annually over the past ten years. The bulk of Arkansas's wheat production is found in the eastern delta areas of the state, where it is grown as a secondary crop in rice and cotton production areas (Figure 1). Not many farmers in Arkansas are taking advantage of wheat's potential to provide income in the form of cattle weight gain, as is the case in Oklahoma and Texas. This may be attributed to the fact that wheat is grown primarily in one part of the state (Figure 1) while cattle populations are located in another (Figure 2). This situation results in limited areas where these two enterprises coexist. Unfortunately, many calves are leaving the state, and they will be grazed on wheat in western states before going into a feedlot.

Historically, calves are cheaper in the fall when large runs of spring-born calves are marketed. This presents an opportunity to capture added value through improved market conditions for the wheat farmer. Wheat is very high-quality forage, and when used for grazing, calves can achieve body weight gains of two or more pounds per day.

Research in Oklahoma demonstrated that removing cattle prior to first hollow stem will result in little or no impact on grain yield, which is important to Arkansas wheat producers since 90 percent of the reported acres planted are also harvested. This leaves the option open to either purchase or contract graze a second set of calves in the spring, if greater returns favor the cattle market. Alternatively, cattle can be removed before first hollow stem and a grain crop can be harvested when greater returns favor grain production.

Methods for establishing wheat may include preparing a clean seedbed by deep-tilling the soil prior to planting, no till drilling seed into an undisturbed seedbed or broadcasting seed using a spreader or aerial application into a lightly disturbed seedbed. Producer decisions, such as

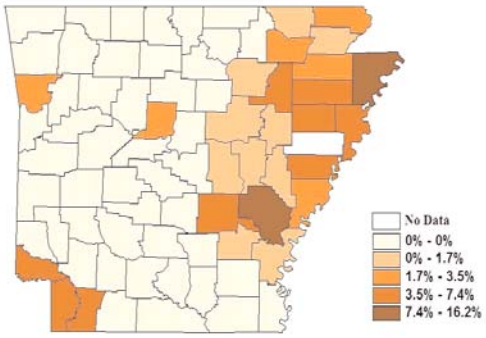

Figure 1. Wheat acres planted – 2005.

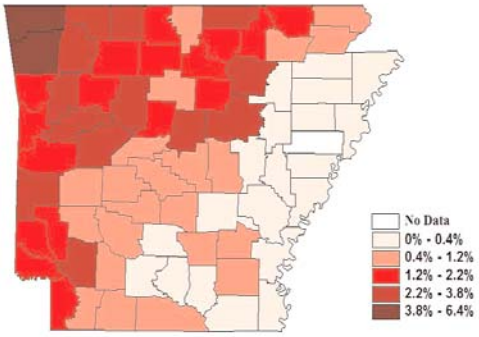

Figure 2. Cattle inventory – 2005.

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tillage method and planting date, can have a large impact on animal performance. No till has become more favorable because of the reduction in time requirements for field preparation, fuel and labor costs and required equipment. Additional benefits of no till for establishment of small grain pastures include fewer planting delays due to wet fields and reduced bogging by livestock.

The following is a summary of a research project supported by the USDA, National Research Initiative program and conducted at the Livestock and Forestry Branch Station (LFBS) near Batesville, Arkansas. The study's purpose was to compare the effects of conventional, no till and minimum tillage establishment of soft red winter wheat on animal performance and grazing days, changes in soil characteristics and costs and returns because of establishment method.

Establishment and Fertility Management

Tillage research began in the fall of 2002. The research was conducted on a silt loam soil (Peridge) with a 0 to 3 percent slope. The following outline describes the process used for establishing wheat at 120 pounds per acre into a disturbed, lightly disturbed or undisturbed seedbed. Fields were planted the first week of September.

Conventional tillage
- Chisel plow cutting to 8-10 inches (2 passes)
- Disking – cutting (2 passes) then finishing (2 passes)
- Roller harrow
- Drill seed

Light disk and broadcast (minimal tillage)
- Glyphosate (2 qt/acre) application, 7 days before planting
- One pass with a finish disk to scratch the soil surface
- Broadcast seed via fertilizer buggy

No till drill
- Glyphosate (2 qt/acre) application, 7 days before planting
- No till drill seed

Fertilizer was spread at a rate of 60 lb/acre actual nitrogen at planting, and a second application was applied during the last two weeks of February.

Soil and Water Quality

In the past, soil and water quality were not reasons for adopting specific farming practices. Today, a number of reasons make conservation tillage practices a better management choice than more traditional tillage-intensive practices. One immediate reason is reduced cost associated with conservation tillage. Another is maintaining or improving the natural resource base, guaranteeing economic production into the future. A third benefit, not always considered by farmers, is maintaining compliance with federal regulations on water quality and preventing problems such as the surplus nutrient areas of western Arkansas. Because most cattle production in Arkansas is on lands that are hilly, any farming practice that increases the movement of soil or water down the slope will contribute to environmental and resource problems.

Keeping these factors in mind, one goal of the conservation tillage study was to evaluate how the three tillage systems impacted soil and water quality. To determine if there had been movement of soil and nutrients down the slope, each field was divided into three areas: top, middle and bottom. Soil samples were collected in each area and analyzed for their nutrient and carbon content.

Average phosphorus levels for the no till and minimum tillage treatments were similar (Table 1), while that for conventional till was much less. These data indicate that phosphorus is being lost from the conventional till field at a much higher rate. When location on slope is considered, phosphorus movement was highest from the middle of the slope for the conventional till field and some movement was observed from the top of the minimum tillage fields. A similar trend was found with potassium and organic matter measurements. From the management standpoint, this shows movement of phosphorus, potassium and organic matter down slopes and, in some cases, off the field when conventional tillage is practiced. This not only represents a loss of soil nutrients that must be replaced with fertilizer but, more importantly, a change in soil nutrient levels along the slope. This transition makes it difficult to determine the fertilizer level to apply to the field. Fertilizer rates that are correct for the top, middle or bottom of the field might not be appropriate for the rest of the field. Any given fertilizer rate would likely be high for some areas within the field and could be considered a wasted input or low for other areas within the field, limiting productivity. The nearly uniform values for no till mean a producer can expect a more uniform response among different areas of the field when using a single fertilizer level.

One measurement of soil quality is the abundance (%) of water-stable aggregates. These are small collections of minerals, organic matter and organic substances formed in the soil. Because they are larger than minerals, they are more difficult to move across the field and do not compact, which leads to better water movement into the soil. Soil samples were collected from the same areas measured for nutrient content. These samples were processed to determine the percent water-stable aggregates in five size classes ranging from 0.25 to 4.00 mm diameter.

Table 1. Soil phosphorus (P), potassium (K) and organic matter (OM) levels from samples collected at the top, middle and bottom of fields that were no till, minimum till or conventional till managed.

Measurement	Tillage	Location on Slope			
		Top	Middle	Bottom	Average
		Expressed as pounds per acre			
Phosphorus	No till	160	160	154	158
	Minimum till	136	170	176	160
	Conventional till	156	118	152	142
Potassium	No till	446	454	516	472
	Minimum till	444	442	540	476
	Conventional till	470	376	508	452
Expressed as percent (%)					
Organic matter	No till	2.31	2.23	2.26	2.27
	Minimum till	2.28	2.15	2.27	2.24
	Conventional till	2.19	2.00	2.24	2.15

Apart from very high values in the middle of the field for the no till managed field, the percent total water-stable aggregates followed the same trends as phosphorus, potassium and organic matter. Aggregate stability values were similar for all tillage treatments at the bottom of the fields but varied considerably at the top and middle of the slope (Figure 3). These data indicate there will be differences in how much water moves into the soil, the volume of nutrients available in the soil and how much soil moves off the field when it rains.

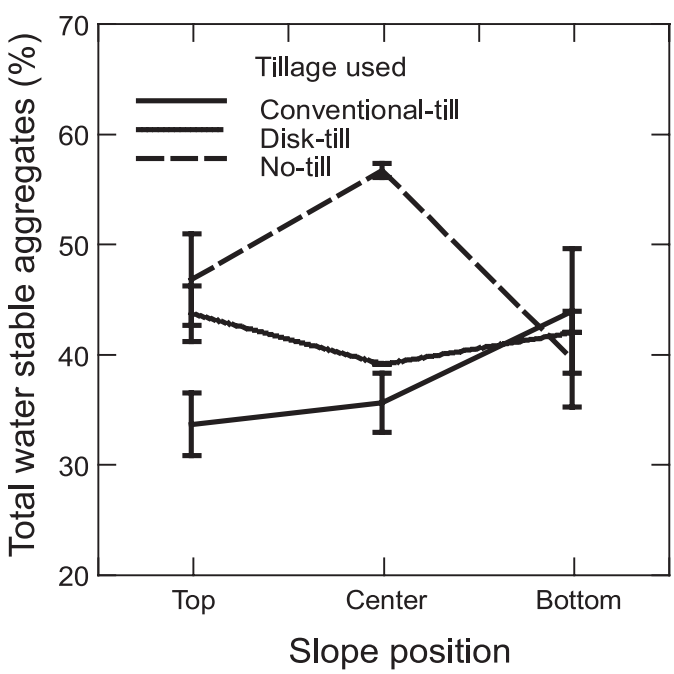

Figure 3. Comparison of total percentage of water-stable soil aggregates, by weight, found in the top 5 cm of soil samples collected from the top, center and bottom of fields that were conventional till, minimum till and no till managed for winter wheat grazing.

To determine if the different tillage treatments affected the amount of rainfall moving off the fields, a rainfall simulation device was used to create a 30-minute rainfall event. Measurements were only taken from the middle portion of each treatment during September 2005. The amount of rainfall running off the plots and its quality were determined.

Percent soil cover (Table 2) illustrated one of the biggest differences between tillage approaches. A very high percentage of cover (non-wheat) remains on the no till plots which, in turn, impacts the amount of water running off the field. A reduction in the amount of time for runoff to begin occurred as tillage intensity increased. Earlier commencement of runoff resulted in a higher volume of water moving off the field. A slowing in the time to runoff and less water moving off the field mean that more water moves into the soil and is available for plant growth.

Total nitrogen and phosphorus carried off the field were measured. Total nitrogen carried off the field was the same for the minimum and conventional till fields but lower for the no till field.

Table 2. Percent cover, time to runoff, runoff volume and runoff values obtained from rainfall simulations taken in the middle slope area of fields that were no till, minimum till or conventional till managed for September 2005.

Tillage	Cover (%)	Time to runoff (min)	Runoff volume (vol/acre)	Runoff (%)
No till	97	10	4	14
Minimum till	73	8	11	38
Conventional till	4	6	15	54

Total phosphorus lost because of runoff was lowest for the no till field (0.1 lb/acre), intermediate for the minimum till field (0.2 lb/acre) and highest for the conventional till field (0.7 lb/acre). These data show that fewer nutrients are moving off the no till field. These results show two advantages: 1) the farmer is not losing nutrients carried off the field as runoff and, thus, these nutrients will not have to be replaced and 2) fewer concerns about pollution in streams that are adjacent to farmer's fields.

Wheat Quality and Calf Production

Calves were not allowed to graze the pastures until plants reached a height of approximately 8 to 10 inches to prevent stand injury. Throughout grazing, forage production and quality were evaluated. Grazing starting and ending dates, animal average daily gain and gain per acre are shown by year because of the effect that weather pattern had on these factors (Table 3). During the 2002-03 grazing season, average daily temperatures (Figure 4) were near the 30-year average, but rainfall accumulation (Figure 5) was normal at planting but below normal throughout the grazing period. The start of grazing (Table 3) was delayed in the fall by 16 days for minimum tillage pastures and 8 days for no till compared to conventionally prepared pastures. Average daily gain (Table 3) in the fall was 0.47 lb per day greater for steers grazing minimum till pastures compared to steers grazing conventionally prepared pastures. Steers grazing no till pastures gained 0.18 lb per day more than steers grazing conventional pastures. In the spring, tillage system did not affect starting or ending dates of grazing, but average daily gain of steers on minimum tilled or no till pastures gained 0.23 and 0.39 lb per day more than steers in conventional pastures, respectively. Total gain per steer in the spring was 20 and 32 lb greater, respectively, for steers grazing minimum and no till pastures than for steers grazing conventional pastures. Total gain per acre (Table 3) was 50 lb greater for conventional pastures compared to minimum tillage pastures, while production of conventional and no till pastures was similar.

During the 2003-04 grazing season, average daily temperatures (Figure 4) and rainfall accumulations (Figure 5) were near normal at planting and throughout the grazing period. The start of grazing (Table 3) was the same for all pastures during the fall and the spring. Average daily gain (Table 3) in the fall was 0.40 lb per day greater and total gain per steer was 34 lb greater for steers grazing no till pastures compared to steers grazing either conventionally prepared pastures or minimum tillage pastures. In the spring, tillage system did not affect starting or ending dates of grazing, average daily gain or total gain of steers. Total gain per acre (Table 3) was 46 lb greater for no till pastures compared to minimum tillage pastures and conventionally prepared pastures.

During the 2004-05 grazing season, average daily temperatures (Figure 4) during the fall were above the 30-year average, while temperatures in the spring were near average. Rainfall accumulations (Figure 5) were below normal at planting but above normal throughout the grazing period. The start of grazing (Table 3) for no till pastures was 17 and 20 days earlier compared to conventionally prepared pastures and minimum tillage pastures during the fall. Average daily gain (Table 3) in the fall was 0.32 lb per day greater for steers grazing no till pastures compared to steers grazing conventional pastures, and total gain per steer was 36 and 55 lb greater for steers grazing no till pastures compared to steers grazing either conventionally prepared pastures or minimum tillage pastures. In the spring, tillage system did not affect starting or ending dates of grazing or average daily gain, but total gain of steers grazing no till or minimum tillage pastures was 24 and 32 lb greater than steers grazing conventional pastures. Total gain per acre (Table 3) was 89 lb greater for no till pastures compared to conventionally prepared pastures.

During the 2005-06 grazing season, average daily temperatures (Figure 4) during the fall were near the 30-year average while temperatures in the spring were greater than average. Rainfall accumulations (Figure 5) were above normal at planting but below normal throughout the grazing period. Because moisture was adequate at planting for establishment of all pastures, the start of grazing (Table 3) was similar for all pastures in the fall and spring. Average daily gain and total gain per steer (Table 3) were not affected by tillage system during the fall or the spring. Total gain per acre (Table 3) was also not affected by tillage system and was extremely high (average = 633 lb/acre) considering the dry conditions encountered.

Economic Impact

Annual winter wheat and rye forage production budgets were developed for each tillage method for the fall 2003-spring 2006 period using the Mississippi State Budget Generator (Table 4). The budgets were created using input and field operation data from experimental winter small grains pastures at the LFBS. Average per acre forage production budgets are presented by tillage method in Table 7. Both RT and NT have smaller pasture production costs than CT due to savings in labor, fuel and machinery fixed expenses resulting from fewer land preparation operations.

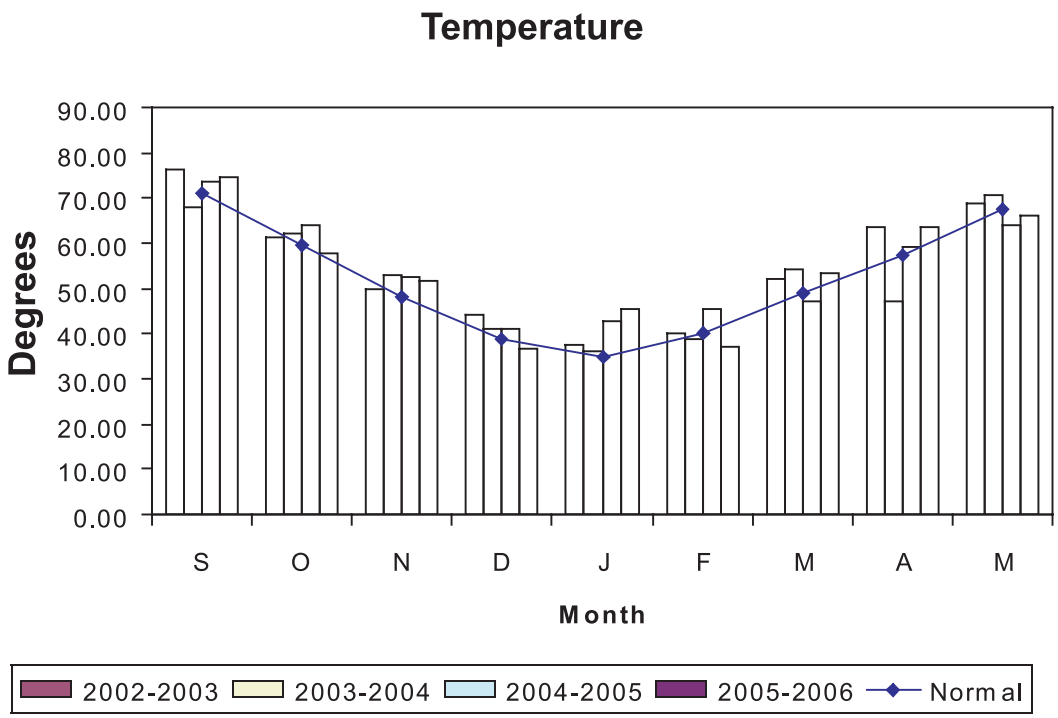

Figure 4. Average daily temperatures compared to the 30-year average.

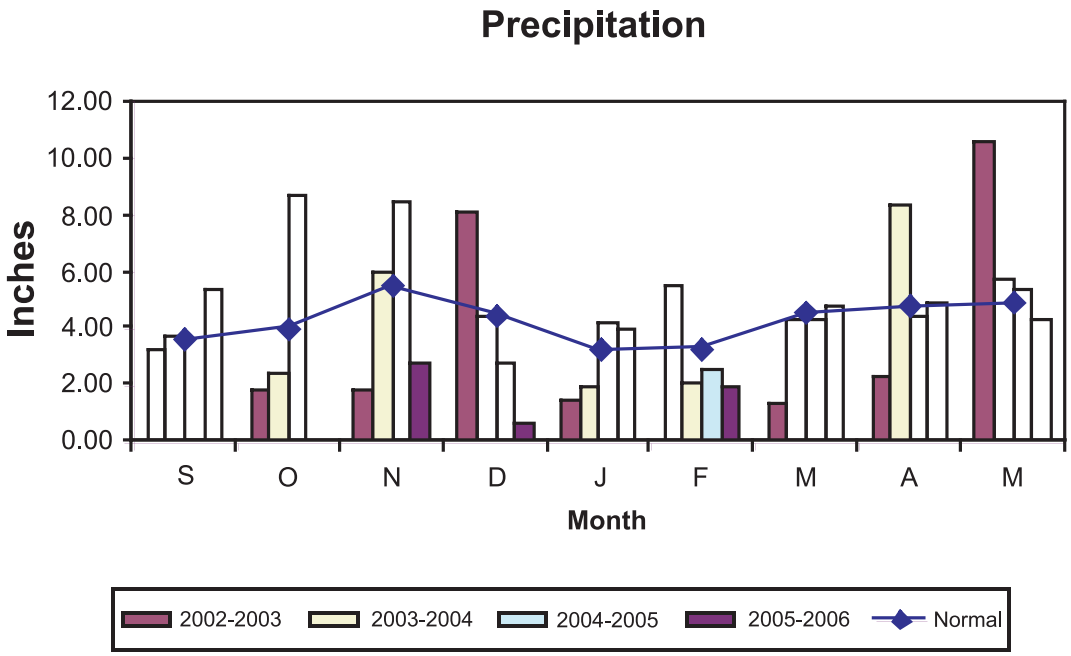

Figure 5. Precipitation accumulation compared to the 30-year average.

Table 3. Effect of tillage system on grazing days and animal performance from fall 2002 to spring 2006.

	Tillage System		
Item	**Conventional**	**Minimum**	**No Till**
Fall/Winter 2002-03			
Grazing Initiation	November 13	November 29	November 21
Grazing Days	79	56	68
Average Daily Gain, lb	1.85	2.32	2.03
Total Gain/Steer, lb	146	131	131
Spring 2003			
Grazing Initiation	February 27	February 25	February 25
Grazing Days	67	70	71
Average Daily Gain, lb	2.01	2.24	2.40
Total Gain/Steer, lb	139	171	159
2002-2003 Overall			
Grazing Days/Acre	301	232	272
Total Gain/Acre, lb	604	554	586
Fall/Winter 2003-04			
Grazing Initiation	October 28	October 28	October 28
Grazing Days	57	57	57
Average Daily Gain, lb	1.04	1.05	1.44
Total Gain/Steer, lb	91	92	125
Spring 2004			
Grazing Initiation	March 2	March 2	March 2
Grazing Days	56	56	56
Average Daily Gain, lb	2.44	2.46	2.41
Total Gain/Steer, lb	137	138	135
2003-2004 Overall			
Grazing Days/Acre	236	236	236
Total Gain/Acre, lb	443	447	491
Fall 2004-05			
Grazing Initiation	December 3	December 6	November 16
Grazing Days	68	51	74
Average Daily Gain, lb	1.66	1.77	1.98
Total Gain/Steer, lb	111	92	147
Spring 2005			
Grazing Initiation	March 9	March 9	March 9
Grazing Days	53	59	61
Average Daily Gain, lb	1.99	2.27	2.21
Total Gain/Steer, lb	106	130	138
2004-2005 Overall			
Grazing Days/Acre	189	189	207
Total Gain/Acre, lb	351	402	440
Fall/Winter 2005-06			
Grazing Initiation	November 18	November 18	November 18
Grazing Days	68	51	74
Average Daily Gain, lb	2.60	2.66	2.73
Total Gain/Steer, lb	234	239	246
Spring 2006			
Grazing Initiation	March 3	March 6	March 6
Grazing Days	53	59	61
Average Daily Gain, lb	2.15	2.31	2.24
Total Gain/Steer, lb	126	124	122
2005-2006 Overall			
Grazing Days/Acre	265	253	250
Total Gain/Acre, lb	641	637	632

Table 4. Average winter wheat and rye forage production expenses by tillage method, fall 2003-spring 2006 (2005 dollars).

Expense Item	CT[a]	RT	NT
	---------- $/Acre ----------		
Crop Seed	24.60	24.60	24.60
Diesel Fuel	23.36	6.71	5.72
Fertilizer and Lime, Fall	53.52	50.45	52.99
Fertilizer, Spring	21.46	22.55	21.78
Herbicides	0.00	14.40	14.40
Operator Labor	20.00	5.78	6.96
Repairs and Maintenance	11.36	3.17	4.36
Operating Interest, Fall	3.73	3.04	3.18
Operating Interest, Spring	1.37	1.36	1.39
Direct Expenses:			
Fall	136.56	108.16	112.22
Spring	22.83	23.92	23.18
Total Direct Expenses	159.39	132.07	135.39
Total Fixed Expenses[b]	23.76	6.52	9.07
Total Specified Expenses	183.15	138.59	144.46

[a]CT = Clean Till, RT = Reduced Till, NT = No Till.
[b]Machinery depreciation and interest expenses.

Table 5. Average receiving expenses by tillage method and grazing period, fall 2003-spring 2006 (2005 dollars).

Expense Item[a]	CT[b]	RT	NT
	---------- Fall ($/Acre) ----------		
Feed and Hay	27.88	28.32	25.36
Labor	3.35	3.35	3.35
Minerals	5.14	5.22	4.67
Vet and Medical	14.05	14.05	14.05
Death Loss[c]	19.47	19.47	19.47
Interest[d]	22.95	22.95	22.95
Checkoff	1.17	1.17	1.17
Hauling	9.37	9.37	9.37
Total	103.36	103.89	100.38
	---------- Spring ($/Acre) ----------		
Feed and Hay	47.74	48.69	48.69
Labor	5.88	5.88	5.88
Minerals	8.79	8.97	8.97
Vet and Medical	20.10	20.10	20.10
Death Loss[c]	42.90	42.90	42.90
Interest[d]	41.37	41.37	41.37
Checkoff	2.51	2.51	2.51
Hauling	20.10	20.10	20.10
Total	189.39	190.52	190.52

[a]Expense items can be converted to dollars per steer by dividing the per acre stocking density. The average fall stocking density is 1.17 steer calves per acre, and the average spring stocking density is 2.51 steer calves per acre for the fall 2003-spring 2006 period.
[b]CT = Clean Till, RT = Reduced Till, NT = No Till.
[c]Death loss calculated as 3.5 percent mortality multiplied by steer purchase value.
[d]Interest is calculated at 9 percent of steer purchase value and weighted by the period of time in months steers are held after purchase (5.5 months for fall steers, 4.5 months for spring steers) divided by 12.

Table 6. Average steer weight data by tillage method and grazing period, fall 2003-spring 2006.

Weight Item	CT[a]	RT	NT
	---------- Fall ----------		
Purchase Weight (lbs/steer)[b]	433	433	433
Initial Grazing Weight (lbs/steer)	486	490	483
Sell Weight (lbs/steer)	631	631	656
Total Gain/Steer (lbs)	145	140	173
Total Gain/Acre (lbs)[c]	170	164	203
	---------- Spring ----------		
Purchase Weight (lbs/steer)	450	450	450
Initial Grazing Weight (lbs/steer)	514	511	517
Sell Weight (lbs/steer)	637	645	646
Total Gain/Steer (lbs)	123	133	129
Total Gain/Acre (lbs)[c]	309	335	324
	-------- Fall Plus Spring --------		
Total Gain/Steer (lbs)	268	274	302
Total Gain/Acre (lbs)	479	499	527

[a]CT = Clean Till, RT = Reduced Till, NT = No Till.
[b]Purchase weight of 425 lb/steer in fall 2003 and fall 2004, purchase weight of 450 lb/steer in fall 2005.
[c]The average fall stocking density is 1.17 steer calves per acre, and the average spring stocking density is 2.51 steer calves per acre for the fall 2003-spring 2006 period.

Table 7. Average net returns above receiving and forage production expenses by tillage method, fall 2003-spring 2006 (2005 dollars).

Economic Item	CT[a]	RT	NT
	----- Fall ($/Acre) -----		
Gross Returns[b]	702.18	701.44	729.62
Purchase Expenses[c]	556.26	556.26	556.26
Receiving Expenses	103.36	103.89	100.38
Net Returns above Receiving Expenses, Fall	42.56	41.29	72.98
	----- Spring ($/Acre) -----		
Gross Returns[d]	1536.09	1553.77	1556.98
Purchase Expenses[e]	1225.80	1225.80	1225.80
Receiving Expenses	189.39	190.52	190.52
Net Returns above Receiving Expenses, Spring	120.90	137.45	140.66
	----- Net Returns ($/Acre) -----		
Total Returns above Receiving Expenses	163.46	178.74	213.64
Forage Production Expenses	183.15	138.59	144.46
Net Returns above Total Expenses	-19.69	40.15	69.18

[a]CT = Clean Till, RT = Reduced Till, NT = No Till.
[b]Fall steers purchased in mid-September at $109.63/cwt.
[c]Fall steers sold in February at $95.00/cwt.
[d]Spring steers purchased in mid-January at $108.42/cwt.
[e]Spring steers sold in May at $95.93/cwt.

Average steer receiving expenses were estimated on a per acre basis for the fall 2003-spring 2006 period using historical receiving data from the LFBS (Table 5). Feed and hay expenses and mineral expenses were estimated at $0.38/day/steer and $0.07/day/steer, respectively, for each receiving period. Steer receiving began September 15 for the fall period and January 15 for the spring period and continued until the date when steers were turned out onto small grains pastures. Fall receiving periods averaged 63, 64 and 57 days, while spring receiving periods averaged 50, 51 and 51 days for CT, RT and NT, respectively, over the fall 2003-spring 2006 period.

Average steer weight data for the fall 2003-spring 2006 period are presented by tillage method and grazing period in Table 6. The NT strategy had the largest average weight gain during the fall. Steers were turned onto NT small grains pasture earlier in the fall than were steers on RT or CT pasture. Steers grazed on both NT and RT pasture had relatively the same average weight gain during the spring grazing period. The NT strategy had the largest total weight gain over the fall and spring grazing periods (527 lb per acre, 302 lb per steer).

Average per acre net returns above receiving and forage production expenses are presented by tillage method in Table 7. The NT strategy produced the largest average net return ($69.18/acre), followed by the RT strategy ($40.15/acre). The NT strategy was more profitable than the other two tillage strategies because of higher weight gain in the fall. In contrast, the average return to the CT strategy was negative during the fall 2003-spring 2006 period (-$19.69/acre). Forage production expenses were significantly larger for CT than for the other conservation tillage strategies, and returns above receiving expenses for the CT strategy were not large enough to cover forage production expenses.

Expenses for controlling ryegrass were included in the return calculations of Table 7. Ryegrass was controlled in the study to maintain pure plots for accurate wheat and rye forage measurements. Ryegrass would be more of a concern if winter wheat was harvested for grain in addition to being grazed by steers. Cattle producers may not be concerned with ryegrass in a typical grazeout strategy in which wheat is not harvested for grain. However, producers would incur the same costs if they wished to control for other grass species, like bermudagrass or fescue, prior to planting winter small grains forage.

The cost of ryegrass control was $21.46/acre for CT (cost of disking twice in the summer following grazing) and $10.13/acre for both RT and NT (the cost of applying glyphosate following grazing). If ryegrass was not a concern, average net returns over the fall 2003-spring 2006 period would be $1.80/acre for CT, $50.28/acre for RT and $79.31/acre for NT.

Conclusions

Increased and more uniform soil nutrient levels, improved soil quality, more water moving into the soil, less water and nutrients moving off the field and improved quality of the water moving off the field are all advantages observed with no till managed fields over minimum till and conventional till managed fields. Producers can benefit from these advantages by being able to uniformly apply fertilizer across fields at a rate that results in the best efficiency for that field and by being able to reduce fertilizer levels because fewer nutrients are lost from the field during rainfall events. There will be less runoff to manage at the bottom of fields and fewer chances that runoff will result in downstream problems. Maintaining and/or enhancing soil and water quality will ensure a good resource base for years of production.

No till establishment of small grain fields for grazing is superior to conventional tillage and minimum tillage when fall rains are delayed and the soil water profile can be maintained by chemical fallow during the summer. In years with adequate precipitation in the fall for small grain seedling emergence and growth, no difference was noted among tillage systems. This indicates that if weather risks and costs of production can be reduced through no till, then superior economic performance would be expected. Economic analysis of the combined years indicated an economic advantage for reduced tillage and no till establishment of wheat for grazing because of reduced establishment costs.

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