

**Water Quality Indices and Net Returns for
Crop Rotations in the Lower Arkansas Watershed**

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Abstract

This paper examines water quality indices and net returns for a continuous wheat and a grain sorghum-wheat rotation in the Lower Arkansas Watershed. Reducing tillage was found to substantially improve soil erosion, N transport, and P transport for both the continuous wheat and grain sorghum-wheat rotations. The change in surface runoff was not as pronounced or consistent across rotations and soil types as the other water quality measures. Soil erosion was relatively higher for the continuous wheat rotation. However, for the continuous wheat rotation, N transport and P transport were significantly lower in comparison to the values for the grain sorghum-wheat rotation. Reducing tillage lowered production cost per acre for the continuous wheat rotation. For the grain sorghum-wheat rotation, depending on the practice, the impact of reducing tillage on production cost per acre ranged from -3.2% to 12.9%.

Introduction

Water quality issues associated with production agriculture have become increasingly important in recent years. Assuming that farmers are choosing crop rotations with the highest net return per acre, there may be a cost associated with improving water quality parameters. Therefore, policy makers, farmers, and extension personnel are interested in the practices that may improve water quality and the associated cost of these practices.

This white paper is part of a six part series that summarizes the results of a KDHE funded project that examined water quality indices and production cost per acre for typical crop rotations found in the Upper Delaware, Lower Blue, Lower Kansas, Lower Arkansas, Middle Arkansas, and Upper Arkansas watersheds. The overall objective of the project was to examine the tradeoff between net return per acre and water quality for representative non-irrigated crop rotations in each watershed. Results for the Lower Arkansas Watershed are summarized in this paper.

Methods

The Erosion Productivity Impact Calculator (EPIC) model was used to simulate water quality parameters for each specific non-irrigated crop rotation. EPIC was designed to determine the effect of management strategies on agricultural production and soil and water resources. Input data for the EPIC model included historical weather data; soil type; tillage practices; and fertilizer, herbicide, and insecticide application amounts.

Several major soil types were used to compare water quality parameters across crop rotations and practices. Specifically, soils used to compute water quality parameter

indices included Ladysmith in Harper county; Farnum in Sedgwick county; and Bethany in Sumner county.

To facilitate comparisons among non-irrigated crop rotations, a base crop rotation was selected for each watershed. This base crop rotation was assigned an index value of 1.000 for each water quality parameter. An index value for each water quality parameter was created for all of the other non-irrigated crop rotations by comparing the water quality parameter of a specific crop rotation to the water quality parameter for the base crop rotation. An index value greater than 1.000 indicates that the crop rotation has a less desirable level of the water quality parameter. Conversely, an index value less than 1.000 indicates that the crop rotation has a more desirable level of the water quality parameter. The four categories of water quality parameters used were as follows: soil erosion, surface runoff, N transport (organic nitrogen loss with sediment), and P transport (phosphorus loss with sediment).

Net return budgets were developed for a continuous wheat rotation and a grain sorghum-wheat rotation. Separate net return budgets were developed for conservation tillage and no-till practices. Gross returns were derived from KSU Farm Management Guides for south central Kansas (www.agmanager.info). Costs associated with seed, fertilizer, herbicide, field operations, non-machinery labor, interest, and miscellaneous items were included in the net return budgets. The costs associated with seed, drying, non-machinery labor, interest, and miscellaneous items were derived from KSU Farm Management Guides for south central Kansas. Fertilizer costs were computed using the fertilizer amounts used in the EPIC model and prices reported in Kastens et al. (2005). Herbicide costs were computed using the herbicide amounts used in the EPIC model and

prices reported in Regehr et al. (2005). The field operations used for each rotation and tillage practice are reported in Tables 1-4. The field operations listed in these tables were used in both the EPIC model and net return budgets. Grain hauling charges were included as a field operation cost in the net return budgets. Specific dates are reported in Tables 1-4 because this information is required for the EPIC model.

Table 5 contains the crop rotation abbreviations used in the discussion below. Alternative #1 for the conservation tillage rotations eliminated the tandem disk and first field cultivation operations in the continuous wheat rotation and the chisel operation for grain sorghum in the grain sorghum-wheat rotation. Alternative #2 for the conservation tillage rotations eliminated the cultivation in Alternative #1 and broadcasted nitrogen instead of knifing anhydrous ammonia in the first fertilizer application for grain sorghum in the grain sorghum-wheat rotation. Alternative #1 for the grain sorghum-wheat no-till rotation broadcasted nitrogen instead of knifing anhydrous ammonia in the first fertilizer application for grain sorghum.

The continuous wheat conservation tillage base rotation was used as the base for water quality parameter comparisons. The continuous wheat conservation tillage base rotation was used to compare cost changes across the continuous wheat rotations. Similarly, the grain sorghum-wheat conservation tillage base rotation was used to compare cost changes across the grain sorghum-wheat rotations.

Water Quality Indices

Water quality indices for soil erosion are presented in Table 6. Eliminating the tillage operations reduced soil erosion substantially in both rotations. For the continuous wheat rotation the reduction ranged from 24.5% for Farnum soil Sedgwick county to

45.5% for Bethany soil in Sumner county. For the grain sorghum-wheat rotation the reduction in soil erosion ranged from 15.4% for Bethany soil Sumner county to 19.4% for Farnum soil in Sedgwick county. For the continuous wheat rotation, the no-till rotation had soil erosion levels that were relatively lower than the base rotation, but relatively higher than the reduced tillage scenario for conservation tillage rotation. For the grain sorghum-wheat rotations, the no-till base rotation had relatively lower levels of soil erosion than the reduced tillage scenario for the conservation tillage rotation.

Table 7 reports the surface runoff indices for the continuous wheat and grain sorghum-wheat rotations. Unlike the other water quality parameters, the impact of reducing tillage on surface runoff was not as pronounced or as consistent across crop rotations and soil types. The largest reduction in surface runoff occurred when tillage was reduced for the grain sorghum-wheat rotation for Farnum soil in Sedgwick county.

The N transport and P transport water quality indices are reported in Table 8 and Table 9. The results for these two measures are quite similar. A significant improvement in N transport and P transport was obtained by reducing tillage. Also, it is worthy to note that the N transport and P transport indices for Alternative #2 for the grain sorghum-wheat rotation were lower than the indices for the base rotation, but were higher than the indices for Alternative #1. Also, the N transport and P transport indices were significantly higher for the grain sorghum-wheat rotation in comparison to the continuous wheat rotation.

Net Return Budgets

Cost comparisons among crop rotations can be found in Table 10, Table 11, and Table 12. Table 10 reports the budget for the continuous wheat conservation tillage base

rotation. Table 11 reports the budget for the grain sorghum-wheat conservation tillage base rotation. Table 12 reports the estimated cost differences between the rotations. In Table 12, the continuous wheat conservation tillage base rotation is used to compare cost differences among the continuous wheat rotations, and the grain sorghum-wheat conservation tillage base rotation is used to compare cost differences among the grain sorghum-wheat rotations. A positive number in Table 12 indicates that production cost per acre is relatively higher with the adoption of a specific practice. Conversely, a negative number indicates that production cost per acre is relatively lower with the adoption of a specific practice.

Using the results reported in Table 12, eliminating the tandem disk and first field cultivation operations reduced cost per acre by \$14.89 for the continuous wheat rotation. Eliminating the chisel operation for grain sorghum in the grain sorghum-wheat rotations reduced cost per acre by \$4.23. As noted in the previous section, eliminating these tillage operations also improved soil erosion, N transport, and P transport. The net return analysis in this paper does not consider changes in crop yields or risk that may occur when eliminating these tillage operations. These items would need to be taken into account before a decision to eliminate these tillage operations was implemented. However, given the potential reduction in cost and potential improvement in water quality, eliminating tillage operations seems to be a practice that warrants additional consideration.

Adopting no-till practices involves a reduction in tillage, which reduces field operation cost, and an increase in herbicide cost. Adopting no-till practices resulted in lower cost per acre for the continuous wheat rotation and higher cost per acre for the

grain sorghum-wheat rotation in this study (Table 12). Previous research that has examined the impact of adopting a no-till practice or reducing tillage on production cost is inconclusive. The North Central Kansas Farm Management Association conducts an annual cost analysis of no-till farms and other crop farms. The results consistently show that production cost per harvested acre is similar for these two types of farms. It is important to note, however, that the cost mix does differ between no-till and other crop farms. No-till farms have relatively lower per acre labor, machine hire, fuel, and depreciation costs, and relatively higher seed and herbicide costs per acre. In contrast to the North Central Kansas Farm Management Association no-till study, Langemeier (2005) found that farms that had reduced tillage were relatively more cost efficient or had lower per acre production costs. The improvement in cost efficiency was particularly pronounced in western Kansas.

In summary, reducing tillage was found to substantially improve soil erosion, N transport, and P transport. Reducing tillage lowered production cost per acre for the continuous wheat rotation. For the grain sorghum-wheat rotation, depending on the practice, the impact of reducing tillage on production cost per acre ranged from -3.2% to 12.9%. To the extent that water quality is an important public policy issue, an incentive system to encourage practices that reduce tillage operations seems to have merit.

References

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Table 1. Field Operations for the Continuous Wheat Conservation Tillage Rotation.

Continuous Wheat: Base Case

Tandem Disk	1-Aug
Field cultivate	15-Sep
Field cultivate	15-Oct
Fertilizer application	16-Oct
Plant wheat	16-Oct
Fertilizer application	6-Feb
Herbicide application	6-Feb
Harvest wheat	1-Jul

Alternative #1

- Eliminate tandem disk tillage operation.
 - Eliminate first field cultivation tillage operation.
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Table 2. Field Operations for the Continuous Wheat No-Till Rotation.

Continuous Wheat: Base Case

Herbicide application	10-Aug
Herbicide application	20-Sep
Fertilizer application	16-Oct
Plant wheat	16-Oct
Fertilizer application	6-Feb
Harvest wheat	1-Jul

Table 3. Field Operations for the Grain Sorghum-Wheat Conservation Tillage Rotation.

Grain Sorghum: Base Case

Chisel	15-Aug
Fertilizer application	5-May
Field cultivate	15-May
Fertilizer application	25-May
Herbicide application	25-May
Plant grain sorghum	25-May
Harvest grain sorghum	25-Sep

Wheat: Base Case

Field cultivate	1-Oct
Fertilizer application	16-Oct
Plant wheat	16-Oct
Harvest wheat	1-Jul

Alternative #1

Eliminate chisel tillage operation.

Alternative #2

Eliminate chisel tillage operation.
Broadcast nitrogen instead of knifing anhydrous ammonia.

Table 4. Field Operations for the Grain Sorghum-Wheat No-Till Rotation.

Grain Sorghum: Base Case

Herbicide application	10-Aug
Herbicide application	15-Oct
Fertilizer application	5-May
Herbicide application	10-May
Herbicide application	10-May
Fertilizer application	25-May
Plant grain sorghum	25-May
Harvest grain sorghum	25-Sep

Wheat: Base Case

Fertilizer application	16-Oct
Plant wheat	16-Oct
Harvest wheat	1-Jul

Alternative #1

Broadcast nitrogen instead of knifing anhydrous ammonia.

Table 5. Crop Rotation Abbreviations.

WCTB	Continuous Wheat Conservation Tillage Base Rotation
WCT1	Continuous Wheat Conservation Tillage Alternative #1
WNTB	Continuous Wheat No-Till Base Rotation
GWCTB	Grain Sorghum-Wheat Conservation Tillage Base Rotation
GWCT1	Grain Sorghum-Wheat Conservation Tillage Alternative #1
GWCT2	Grain Sorghum-Wheat Conservation Tillage Alternative #2
GWNTB	Grain Sorghum-Wheat No-Till Base Rotation
GWNT1	Grain Sorghum-Wheat No-Till Alternative #1

Table 6. Soil Erosion Indices for Continuous Wheat and Grain Sorghum-Wheat Rotations.

County Soil Type	HA Ladysmith	SE Farnum	SU Bethany
<u>Continuous Wheat Rotation</u>			
WCTB	1.000	1.000	1.000
WCT1	0.596	0.755	0.545
WNTB	0.879	0.967	0.598
<u>Grain Sorghum-Wheat Rotation</u>			
GWCTB	0.875	0.581	0.883
GWCT1	0.724	0.468	0.747
GWCT2	0.863	0.597	0.762
GWNTB	0.698	0.463	0.718
GWNT1	0.846	0.594	0.731

County Abbreviations:

HA = Harper
 SE = Sedgwick
 SU = Sumner

Table 7. Surface Runoff Indices for Continuous Wheat and Grain Sorghum-Wheat Rotations.

County Soil Type	HA Ladysmith	SE Farnum	SU Bethany
<u>Continuous Wheat Rotation</u>			
WCTB	1.000	1.000	1.000
WCT1	0.990	0.936	1.016
WNTB	0.973	0.918	0.991
<u>Grain Sorghum-Wheat Rotation</u>			
GWCTB	0.978	0.863	0.976
GWCT1	0.950	0.646	0.938
GWCT2	0.957	0.732	0.943
GWNTB	0.949	0.641	0.937
GWNT1	0.955	0.734	0.941

County Abbreviations:

HA = Harper
 SE = Sedgwick
 SU = Sumner

Table 8. N Transport Indices for Continuous Wheat and Grain Sorghum-Wheat Rotations.

County Soil Type	HA Ladysmith	SE Farnum	SU Bethany
<u>Continuous Wheat Rotation</u>			
WCTB	1.000	1.000	1.000
WCT1	0.268	0.149	0.191
WNTB	0.371	0.239	0.201
<u>Grain Sorghum-Wheat Rotation</u>			
GWCTB	1.863	1.934	2.057
GWCT1	0.805	0.682	0.795
GWCT2	1.096	0.960	0.813
GWNTB	0.748	0.630	0.744
GWNT1	1.048	0.934	0.779

County Abbreviations:

HA = Harper
 SE = Sedgwick
 SU = Sumner

Table 9. P Transport Indices for Continuous Wheat and Grain Sorghum-Wheat Rotations.

County Soil Type	HA Ladysmith	SE Farnum	SU Bethany
<u>Continuous Wheat Rotation</u>			
WCTB	1.000	1.000	1.000
WCT1	0.366	0.212	0.260
WNTB	0.172	0.112	0.102
<u>Grain Sorghum-Wheat Rotation</u>			
GWCTB	1.087	1.147	1.219
GWCT1	0.498	0.442	0.501
GWCT2	0.696	0.635	0.517
GWNTB	0.460	0.402	0.462
GWNT1	0.675	0.624	0.490

County Abbreviations:

HA = Harper
SE = Sedgwick
SU = Sumner

Table 10. Cost-Return Budget for the Continuous Wheat Conservation Tillage Base Rotation.

	Wheat
INCOME PER ACRE	
Yield per Acre	45
Price per Bushel	3.21
Net Government Payments	17.16
Indemnity Payments	0.00
Miscellaneous Income	0.00
Returns/Acre	\$161.61
COSTS PER ACRE	
Seed	5.40
Herbicide	6.49
Insecticide/Fungicide	0.00
Fertilizer and Lime	26.25
Crop Consulting	0.00
Crop Insurance	0.00
Drying	0.00
Field Operations	67.51
Non-Machinery Labor	8.90
Miscellaneous	5.75
Sub-Total	\$120.30
Interest	4.81
Total Costs Excluding Land Charge	\$125.11
RETURNS TO LAND AND MANAGEMENT	\$36.50

Table 11. Cost-Return Budget for the Grain Sorghum-Wheat Conservation Tillage Base Rotation.

	Sorghum	Wheat	Rotation
INCOME PER ACRE			
Yield per Acre	80	45	
Price per Bushel	2.24	3.21	
Net Government Payments	17.16	17.16	
Indemnity Payments	0.00	0.00	
Miscellaneous Income	0.00	0.00	
Returns/Acre	\$196.36	\$161.61	\$178.99
COSTS PER ACRE			
Seed	8.85	9.00	
Herbicide	34.41	0.00	
Insecticide/Fungicide	0.00	0.00	
Fertilizer and Lime	46.75	10.50	
Crop Consulting	0.00	0.00	
Crop Insurance	0.00	0.00	
Drying	0.00	0.00	
Field Operations	74.13	44.35	
Non-Machinery Labor	8.31	8.90	
Miscellaneous	5.75	5.75	
Sub-Total	\$178.19	\$78.50	\$128.35
Interest	7.13	3.14	5.13
Total Costs Excluding Land Charge	\$185.32	\$81.64	\$133.48
RETURNS TO LAND AND MANAGEMENT	\$11.04	\$79.97	\$45.50

Table 12. Estimated Cost Differences Between Rotations.

	Change in Cost
<u>Continuous Wheat Rotations</u>	
WCTB	\$0.00
WCT1	-\$14.89
WNTB	-\$8.34
<u>Grain Sorghum-Wheat Rotations</u>	
GWCTB	\$0.00
GWCT1	-\$4.23
GWCT2	\$4.21
GWNTB	\$8.79
GWNT1	\$17.22
