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

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Abstract

This paper examines water quality indices and net returns for a corn-soybean rotation and a grain sorghum-soybean-wheat rotation in the Lower Blue Watershed. Reducing tillage had a marginal impact on production cost per acre, but was found to substantially improve soil erosion, N transport, and P transport for both the corn-soybean and grain sorghum-soybean-wheat rotations. Improvements in levels of soil erosion, surface runoff, N transport, and P transport across crop rotations varied by water quality parameter and soil type.

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 Kansas 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 Gosport in Leavenworth county; Kenoma in Osage county; Knox in

Wyandotte county; Martin in Douglas and Shawnee counties; Pawnee in Jefferson county, and Polo in Johnson 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 corn-soybean rotation and a grain sorghum-soybean-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 northeast 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 northeast 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 fall chisel following corn or grain sorghum, and the early spring field cultivation for soybeans. 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 corn or grain sorghum. Alternative #1 for the no-till rotations broadcasted nitrogen instead of knifing anhydrous ammonia in the first fertilizer application for corn or grain sorghum.

Alternative #2 for the corn-soybean conservation tillage rotation was used as the base for water quality parameter comparisons. The corn-soybean conservation tillage base rotation was used to compare cost changes across the corn-soybean rotations. Similarly, the grain sorghum-soybean-wheat conservation tillage base rotation was used to compare cost changes across the grain sorghum-soybean-wheat rotations.

Water Quality Indices

Water quality indices for soil erosion are presented in Table 6. Eliminating the fall tillage following corn or grain sorghum, and the early spring field cultivation for soybeans reduced soil erosion substantially. For the corn-soybean rotation the reduction ranged from 6.9% for Knox soil in Wyandotte county to 22.0% for Martin soil in

Douglas county. For the grain sorghum-soybean-wheat rotation the reduction in soil erosion ranged from 6.2% for Gosport soil in Leavenworth county to 14.1% for Kenoma soil in Osage county. Additional reductions in soil erosion were possible with no-till practices. For the corn-soybean rotation, the no-till base rotation exhibited soil erosion levels that were from 8.5% to 23.0% lower than the levels for the CSCT2 rotation. For the grain sorghum-soybean-wheat rotation, the no-till base rotation exhibited soil erosion levels that were from 0.9% to 9.8% lower than the levels for the GSWCT2 rotation.

Table 7 reports the surface runoff indices for the corn-soybean and grain sorghum-soybean-wheat rotations. Unlike the other water quality parameters, there was not much difference in surface runoff indices among rotations or tillage scenarios.

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 large improvement in N transport and P transport was obtained by reducing tillage within both rotations. Also, it is worthy to note that the improvement in N transport and P transport obtained by broadcasting N instead of knifing anhydrous ammonia was relatively small.

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 corn-soybean conservation tillage base rotation. Table 11 reports the budget for the grain sorghum-soybean-wheat conservation tillage base rotation. Table 12 reports the estimated cost differences between the rotations. In Table 12, the corn-soybean conservation tillage base rotation is used to compare cost differences among the corn-soybean rotations, and the grain sorghum-soybean-wheat rotation is used to compare cost differences among the grain sorghum-soybean-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 fall chisel following corn or grain sorghum, and early spring field cultivation for soybeans reduced cost per acre by $7.79. 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 the fall chisel following corn or grain sorghum, and early field cultivation for soybeans certainly 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. The net effect of adopting no-till practices on production cost per acre is relatively small 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 had a marginal impact on production cost per acre, but was found to substantially improve soil erosion, N transport, and P transport. 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.

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Table 1. Field Operations for the Corn-Soybean Conservation Tillage Rotation.

Corn: Base Case

Fertilizer application	5-Apr
Field cultivate	15-Apr
Herbicide application	15-Apr
Fertilizer application	16-Apr
Plant corn	16-Apr
Herbicide application	20-May
Harvest corn	1-Oct

Soybeans: Base Case

Chisel	5-Nov
Field cultivate	15-Apr
Field cultivate	14-May
Plant soybeans	16-May
Herbicide application	14-Jun
Harvest soybeans	1-Oct

Alternative #1

Eliminate fall chisel following corn.
Eliminate early spring field cultivation for soybeans.

Alternative #2

Eliminate fall chisel following corn.
Eliminate early spring field cultivation for soybeans.
Broadcast nitrogen instead of knifing anhydrous ammonia.

Table 2. Field Operations for the Corn-Soybean No-Till Rotation.

<u>Corn: Base Case</u>	
Fertilizer application	5-Apr
Fertilizer application	16-Apr
Herbicide application	16-Apr
Herbicide application	16-Apr
Plant corn	16-Apr
Herbicide application	20-May
Harvest corn	1-Oct
<u>Soybeans: Base Case</u>	
Herbicide application	30-Apr
Plant soybeans	5-May
Herbicide application	1-Jun
Harvest soybeans	1-Oct
<u>Alternative #1</u>	
Broadcast nitrogen instead of knifing anhydrous ammonia.	

Table 3. Field Operations for the Grain Sorghum-Soybean-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 sorghum	25-May
Harvest sorghum	25-Sep

Soybeans: Base Case

Chisel	5-Nov
Field cultivate	15-Apr
Field cultivate	14-May
Plant soybeans	16-May
Herbicide application	15-Jun
Herbicide application	1-Jul
Harvest soybeans	1-Oct

Wheat: Base Case

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

Alternative #1

Eliminate fall chisel for grain sorghum.
Eliminate early spring field cultivation for soybeans.

Alternative #2

Eliminate fall chisel for grain sorghum.
Eliminate early spring field cultivation for soybeans.
Broadcast nitrogen instead of knifing anhydrous ammonia.

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

<u>Grain Sorghum: Base Case</u>	
Herbicide application	10-Aug
Herbicide application	15-Oct
Fertilizer application	5-May
Fertilizer application	25-May
Herbicide application	25-May
Herbicide application	25-May
Plant sorghum	25-May
Harvest sorghum	25-Sep
<u>Soybeans: Base Case</u>	
Herbicide application	11-May
Plant soybeans	16-May
Herbicide application	1-Jun
Herbicide application	1-Jul
Harvest soybeans	1-Oct
<u>Wheat: Base Case</u>	
Fertilizer application	16-Oct
Plant wheat	16-Oct
Harvest wheat	1-Jul

<u>Alternative #1</u>

Broadcast nitrogen instead of knifing anhydrous ammonia.

Table 5. Crop Rotation Abbreviations.

CSCTB	Corn-Soybean Conservation Tillage Base Rotation
CSCT1	Corn-Soybean Conservation Tillage Alternative #1
CSCT2	Corn-Soybean Conservation Tillage Alternative #2
CSNTB	Corn-Soybean No-Till Base Rotation
CSNT1	Corn-Soybean No-Till Alternative #1
GSWCTB	Grain Sorghum-Soybean-Wheat Conservation Tillage Base Rotation
GSWCT1	Grain Sorghum-Soybean-Wheat Conservation Tillage Alternative #1
GSWCT2	Grain Sorghum-Soybean-Wheat Conservation Tillage Alternative #2
GSWNTB	Grain Sorghum-Soybean-Wheat No-Till Base Rotation
GSWNT1	Grain Sorghum-Soybean-Wheat No-Till Alternative #1

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

County Soil Type	DO Martin	JE Pawnee	JO Polo	LV Gosport	OS Kenoma	SH Martin	WY Knox
Corn-Soybean Rotation							
CSCTB	1.284	1.216	1.182	1.125	1.285	1.241	1.080
CSCT1	1.002	1.026	0.961	1.012	1.013	0.995	1.006
CSCT2	1.000	1.000	1.000	1.000	1.000	1.000	1.000
CSNTB	0.770	0.829	0.787	0.915	0.797	0.794	0.878
CSNT1	0.760	0.793	0.816	0.894	0.772	0.787	0.869
Grain Sorghum-Soybean-Wheat Rotation							
GSWCTB	1.190	1.103	0.944	1.077	1.229	1.149	1.031
GSWCT1	1.032	0.981	0.860	1.010	1.056	1.020	0.958
GSWCT2	1.043	0.975	0.874	1.010	1.060	1.032	0.968
GSWNTB	0.954	0.931	0.861	1.001	0.975	0.931	0.923
GSWNT1	0.964	0.920	0.879	0.996	0.971	0.944	0.923

County Abbreviations:

DO = Douglas
JE = Jefferson
JO = Johnson
LV = Leavenworth
OS = Osage
SH = Shawnee
WY = Wyandotte

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

County Soil Type	DO Martin	JE Pawnee	JO Polo	LV Gosport	OS Kenoma	SH Martin	WY Knox
Corn-Soybean Rotation							
CSCTB	1.006	1.006	1.008	1.032	0.996	1.003	1.049
CSCT1	0.997	0.999	0.984	0.998	1.000	0.997	0.997
CSCT2	1.000	1.000	1.000	1.000	1.000	1.000	1.000
CSNTB	0.994	0.999	0.960	1.003	1.001	0.997	0.985
CSNT1	0.998	0.999	0.984	1.000	1.001	0.999	0.992
Grain Sorghum-Soybean-Wheat Rotation							
GSWCTB	0.990	1.051	1.014	1.077	1.003	0.993	1.180
GSWCT1	0.987	1.047	0.996	1.073	1.004	0.990	1.135
GSWCT2	0.989	1.047	1.000	1.073	1.003	0.991	1.137
GSWNTB	0.970	1.030	0.960	1.066	1.004	0.978	1.085
GSWNT1	0.973	1.031	0.961	1.066	1.004	0.980	1.087

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

County Soil Type	DO Martin	JE Pawnee	JO Polo	LV Gosport	OS Kenoma	SH Martin	WY Knox
<u>Corn-Soybean Rotation</u>							
CSCTB	1.477	1.382	1.730	1.227	1.399	1.424	1.489
CSCT1	1.017	1.036	0.961	1.030	1.028	1.013	1.030
CSCT2	1.000	1.000	1.000	1.000	1.000	1.000	1.000
CSNTB	0.833	0.922	0.772	0.965	0.846	0.830	0.903
CSNT1	0.810	0.899	0.809	0.925	0.810	0.807	0.877
<u>Grain Sorghum-Soybean-Wheat Rotation</u>							
GSWCTB	1.434	1.293	1.653	1.161	1.376	1.365	1.432
GSWCT1	1.181	1.049	1.247	1.041	1.150	1.132	1.137
GSWCT2	1.184	1.048	1.279	1.041	1.147	1.135	1.138
GSWNTB	1.040	0.956	0.900	1.029	1.029	1.020	0.980
GSWNT1	1.022	0.953	0.903	1.016	1.010	1.008	0.951

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

County Soil Type	DO Martin	JE Pawnee	JO Polo	LV Gosport	OS Kenoma	SH Martin	WY Knox
Corn-Soybean Rotation							
CSCTB	1.391	1.331	1.638	1.194	1.343	1.355	1.409
CSCT1	1.004	1.029	0.955	1.017	1.015	1.002	1.009
CSCT2	1.000	1.000	1.000	1.000	1.000	1.000	1.000
CSNTB	0.894	0.943	0.841	0.997	0.890	0.885	0.951
CSNT1	0.910	0.943	0.920	0.999	0.887	0.895	0.981
Grain Sorghum-Soybean-Wheat Rotation							
GSWCTB	1.424	1.385	1.629	1.238	1.413	1.362	1.403
GSWCT1	1.209	1.148	1.272	1.116	1.203	1.157	1.145
GSWCT2	1.233	1.154	1.323	1.126	1.213	1.178	1.170
GSWNTB	1.116	1.056	0.947	1.118	1.122	1.098	1.010
GSWNT1	1.146	1.066	0.993	1.132	1.133	1.125	1.032

County Abbreviations:

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OS = Osage
SH = Shawnee
WY = Wyandotte

Table 10. Cost-Return Budget for the Corn-Soybean Conservation Tillage Base Rotation.

	Corn	Soybeans	Rotation
INCOME PER ACRE			
Yield per Acre	110	33	
Price per Bushel	2.31	5.83	
Net Government Payments	13.96	13.96	
Indemnity Payments	0.00	0.00	
Miscellaneous Income	0.00	0.00	
Returns/Acre	$268.06	$206.35	$237.21
COSTS PER ACRE			
Seed	48.60	34.65	
Herbicide	45.74	12.22	
Insecticide/Fungicide	0.00	0.00	
Fertilizer and Lime	39.50	0.00	
Crop Consulting	0.00	0.00	
Crop Insurance	0.00	0.00	
Drying	14.30	0.00	
Field Operations	78.81	63.77	
Non-Machinery Labor	9.04	5.37	
Miscellaneous	8.25	8.25	
Sub-Total	$244.24	$124.26	$184.25
Interest	9.77	4.97	7.37
Total Costs Excluding Land Charge	$254.01	$129.23	$191.62
RETURNS TO LAND AND MANAGEMENT	$14.05	$77.12	$45.59

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

	Sorghum	Soybeans	Wheat	Rotation
INCOME PER ACRE				
Yield per Acre	76	33	50	
Price per Bushel	2.39	5.83	3.39	
Net Government Payments	13.96	13.96	13.96	
Indemnity Payments	0.00	0.00	0.00	
Miscellaneous Income	0.00	0.00	0.00	
Returns/Acre	$195.60	$206.35	$183.46	$195.14
COSTS PER ACRE				
Seed	13.78	34.65	10.80	
Herbicide	34.41	11.11	0.00	
Insecticide/Fungicide	0.00	0.00	0.00	
Fertilizer and Lime	39.50	0.00	10.50	
Crop Consulting	0.00	0.00	0.00	
Crop Insurance	0.00	0.00	0.00	
Drying	9.88	0.00	0.00	
Field Operations	72.98	68.03	38.65	
Non-Machinery Labor	6.81	5.37	5.31	
Miscellaneous	8.25	8.25	8.25	
Sub-Total	$185.61	$127.41	$73.51	$128.84
Interest	7.42	5.10	2.94	5.15
Total Costs Excluding Land Charge	$193.03	$132.50	$76.45	$133.99
RETURNS TO LAND AND MANAGEMENT	$2.57	$73.85	$107.01	$61.14

Table 12. Estimated Cost Differences Between Rotations.

	Change in Cost
Corn-Soybean Rotations	
CSCTB	$0.00
CSCT1	-$7.79
CSCT2	-$0.73
CSNTB	-$3.89
CSNT1	$3.16
Grain Sorghum-Soybean-Wheat Rotations	
GSWCTB	$0.00
GSWCT1	-$5.19
GSWCT2	-$0.49
GSWNTB	$1.51
GSWNT1	$6.21