

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

Michael Langemeier

and

Richard Nelson

June 2006

Michael Langemeier is a Professor in the Department of Agricultural Economics and
Richard Nelson is Department Head and Director of Engineering Extension, Kansas State
University.

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

Abstract

This paper examines water quality indices and net returns for continuous grain sorghum and grain sorghum-wheat rotations in the Middle Arkansas Watershed. Reducing tillage was found to substantially improve soil erosion, surface runoff, N transport, and P transport for both the continuous grain sorghum and grain sorghum-wheat rotations. N transport and P transport water quality indices for the grain sorghum-wheat rotation were substantially lower, indicating an improvement in water quality, than the corresponding indices for continuous grain sorghum. For the continuous grain sorghum rotation, depending on the practice, the impact of reducing tillage on production cost per acre ranged from -4.2% to 17.7%. The impact of reducing tillage on production cost per acre for the grain sorghum-wheat rotation 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 Middle 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 Harney in Barton and Pawnee counties; Pratt in Pratt county; Shellebarger in Reno county; and Crete in Rice 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 grain sorghum 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 chisel operation for grain sorghum in the continuous grain sorghum and grain sorghum-wheat rotations. 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 continuous grain sorghum and grain sorghum-wheat rotations. 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 grain sorghum conservation tillage base rotation was used as the base for water quality parameter comparisons. The continuous grain sorghum conservation tillage base rotation was used to compare cost changes across the continuous grain sorghum 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. For most soil types examined, eliminating the tillage operations reduced soil erosion substantially. For

the continuous grain sorghum rotation, changes in soil erosion ranged from a reduction of 22.6% for Crete soil in Rice county to an increase of 18.7% for Pratt soil in Pratt county. For the grain sorghum-wheat rotation, changes in soil erosion ranged from a reduction of 14.4% for Crete soil in Rice county to an increase of 18.0% for Pratt soil in Pratt county. For both crop rotations, the no-till rotation had soil erosion levels that were similar to that of the reduced tillage scenario for the conservation tillage rotation. Adopting Alternative #2 for the conservation tillage rotation had an adverse impact on soil erosion for both continuous grain sorghum and grain sorghum-wheat.

Table 7 reports the surface runoff indices for the continuous grain sorghum and grain sorghum-wheat rotations. For continuous grain sorghum and grain sorghum-wheat, surface runoff for Alternative #1 for the conservation tillage rotation and for the no-till base rotation was relatively lower than it was for the base conservation tillage rotation. Adopting Alternative #2 for the conservation tillage rotation had an adverse impact on surface runoff for both continuous grain sorghum and grain sorghum-wheat.

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 (i.e., through the adoption of Alternative #1 for the conservation tillage scenario or through the adoption of no-till practices). Adopting Alternative #2 for the conservation tillage rotation had an adverse impact on N transport and P transport for both continuous grain sorghum and grain sorghum-wheat.

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 grain sorghum 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 grain sorghum conservation tillage base rotation is used to compare cost differences among the continuous grain sorghum 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 chisel operation reduced cost per acre by \$8.45 for continuous grain sorghum and \$4.23 for grain sorghum-wheat. As noted in the previous section, with the exception of Pratt soil in Pratt county, eliminating these tillage operations also improved soil erosion, surface runoff, 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 higher cost per acre for both the continuous grain sorghum and grain sorghum-wheat rotations 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, surface runoff, N transport, and P transport. For the continuous grain sorghum rotation, depending on the practice, the impact of reducing tillage on production cost per acre ranged from -4.2% to 17.7%. The impact of reducing tillage on production cost per acre for the grain sorghum-wheat rotation ranged from -3.2% to 17.7%. 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

Dumler, T.J. and C.R. Thompson. "Grain Sorghum Cost-Return Budget in South Central Kansas." Agricultural Experiment Station and Cooperative Extension Service, Kansas State University, MF-575, October 2005.

Dumler, T.J. and C.R. Thompson. "Wheat Cost-Return Budget in South Central Kansas." Agricultural Experiment Station and Cooperative Extension Service, Kansas State University, MF-574, October 2005.

Kastens, T.L., K.C. Dhuyvetter, R. Jones, and T.J. Dumler. "Prices for Crop and Livestock Budgets." Agricultural Experiment Station and Cooperative Extension Service, Kansas State University, MF-1013, October 2005.

Langemeier, M. "Impact of the Adoption of Less Tillage Practices on Overall Efficiency." Paper presented at the Southern Agricultural Economics Association Meeting, Little Rock, Arkansas, February 2005.

North Central Kansas Farm Management Association. *Profitlink Summary, 2004*. Agricultural Experiment Station and Cooperative Extension Service, Kansas State University, May 2005.

Regehr, D.L., D.E. Peterson, W.H. Fick, P.W. Stahlman, and R.E. Wolf. "Chemical Weed Control for Field Crops, Pastures, Rangeland, and Noncropland, 2005." Agricultural Experiment Station and Cooperative Extension Service, Kansas State University, Report of Progress 942, January 2005.

Table 1. Field Operations for the Continuous Grain Sorghum Conservation Tillage Rotations.

Continuous Grain Sorghum: Base Case

Chisel	5-Nov
Fertilizer application	5-May
Field cultivate	17-May
Fertilizer application	25-May
Herbicide application	25-May
Plant grain sorghum	25-May
Herbicide application	25-Jun
Harvest grain sorghum	25-Sep

Alternative #1

Eliminate fall chisel tillage operation.

Alternative #2

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

Table 2. Field Operations for the Continuous Grain Sorghum No-Till Rotations.

Continuous Grain Sorghum: Base Case

Herbicide application	25-Apr
Fertilizer application	5-May
Fertilizer application	25-May
Herbicide application	25-May
Plant grain sorghum	25-May
Herbicide application	25-Jun
Harvest grain sorghum	25-Sep

Alternative #1

Broadcast nitrogen instead of knifing anhydrous ammonia.

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 fall chisel tillage operation.

Alternative #2

Eliminate fall 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.

GCTB	Continuous Grain Sorghum Conservation Tillage Base Rotation
GCT1	Continuous Grain Sorghum Conservation Tillage Alternative #1
GCT2	Continuous Grain Sorghum Conservation Tillage Alternative #2
GNTB	Continuous Grain Sorghum No-Till Base Rotation
GNT1	Continuous Grain Sorghum No-Till Alternative #1
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 Grain Sorghum and Grain Sorghum-Wheat Rotations.

County Soil Type	BA Harney	PA Harney	PR Pratt	RE Shellebarger	RI Crete
<u>Continuous Grain Sorghum Rotation</u>					
GCTB	1.000	1.000	1.000	1.000	1.000
GCT1	0.808	0.788	1.187	0.815	0.774
GCT2	1.274	1.286	1.293	1.937	1.282
GNTB	0.762	0.744	1.211	0.787	0.697
GNT1	0.741	0.724	1.213	0.781	0.672
<u>Grain Sorghum-Wheat Rotation</u>					
GWCTB	0.990	0.974	1.547	1.474	0.853
GWCT1	0.865	0.838	1.826	1.494	0.730
GWCT2	1.022	1.014	1.842	1.673	0.846
GWNTB	0.857	0.831	1.867	1.493	0.715
GWNT1	1.019	1.010	1.892	1.676	0.834

County Abbreviations:

BA = Barton
 PA = Pawnee
 PR = Pratt
 RE = Reno
 RI = Rice

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

County Soil Type	BA Harney	PA Harney	PR Pratt	RE Shellebarger	RI Crete
<u>Continuous Grain Sorghum Rotation</u>					
GCTB	1.000	1.000	1.000	1.000	1.000
GCT1	0.719	0.712	0.894	0.860	0.918
GCT2	1.145	1.146	0.965	1.144	1.021
GNTB	0.705	0.697	0.990	0.804	0.920
GNT1	0.704	0.697	1.038	0.793	0.920
<u>Grain Sorghum-Wheat Rotation</u>					
GWCTB	0.817	0.811	1.010	0.909	0.956
GWCT1	0.656	0.647	1.002	0.782	0.913
GWCT2	0.710	0.702	1.055	0.906	0.932
GWNTB	0.653	0.643	0.987	0.760	0.913
GWNT1	0.706	0.698	1.028	0.896	0.929

County Abbreviations:

BA = Barton
PA = Pawnee
PR = Pratt
RE = Reno
RI = Rice

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

County Soil Type	BA Harney	PA Harney	PR Pratt	RE Shellebarger	RI Crete
<u>Continuous Grain Sorghum Rotation</u>					
GCTB	1.000	1.000	1.000	1.000	1.000
GCT1	0.500	0.498	0.679	0.725	0.430
GCT2	1.282	1.284	1.001	1.082	1.320
GNTB	0.484	0.494	0.586	0.673	0.382
GNT1	0.474	0.482	0.492	0.616	0.370
<u>Grain Sorghum-Wheat Rotation</u>					
GWCTB	0.462	0.461	0.586	0.624	0.394
GWCT1	0.179	0.178	0.302	0.289	0.176
GWCT2	0.243	0.242	0.380	0.379	0.239
GWNTB	0.166	0.165	0.289	0.272	0.164
GWNT1	0.237	0.236	0.349	0.357	0.230

County Abbreviations:

BA = Barton
 PA = Pawnee
 PR = Pratt
 RE = Reno
 RI = Rice

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

County Soil Type	BA Harney	PA Harney	PR Pratt	RE Shellebarger	RI Crete
<u>Continuous Grain Sorghum Rotation</u>					
GCTB	1.000	1.000	1.000	1.000	1.000
GCT1	0.518	0.517	0.619	0.730	0.440
GCT2	1.587	1.589	1.396	1.368	1.643
GNTB	0.495	0.507	0.524	0.668	0.386
GNT1	0.502	0.513	0.448	0.628	0.390
<u>Grain Sorghum-Wheat Rotation</u>					
GWCTB	0.503	0.503	0.564	0.677	0.420
GWCT1	0.210	0.209	0.304	0.333	0.196
GWCT2	0.301	0.300	0.388	0.438	0.292
GWNTB	0.193	0.193	0.288	0.309	0.182
GWNT1	0.300	0.299	0.358	0.412	0.290

County Abbreviations:

BA = Barton
PA = Pawnee
PR = Pratt
RE = Reno
RI = Rice

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

	Sorghum
INCOME PER ACRE	
Yield per Acre	80
Price per Bushel	2.24
Net Government Payments	17.16
Indemnity Payments	0.00
Miscellaneous Income	0.00
Returns/Acre	\$196.36
COSTS PER ACRE	
Seed	8.85
Herbicide	43.91
Insecticide/Fungicide	0.00
Fertilizer and Lime	46.75
Crop Consulting	0.00
Crop Insurance	0.00
Drying	0.00
Field Operations	78.39
Non-Machinery Labor	8.31
Miscellaneous	5.75
Sub-Total	\$191.95
Interest	7.68
Total Costs Excluding Land Charge	\$199.63
RETURNS TO LAND AND MANAGEMENT	-\$3.27

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 Grain Sorghum Rotations</u>	
GCTB	\$0.00
GCT1	-\$8.45
GCT2	\$8.41
GNTB	\$18.54
GNT1	\$35.40
<u>Grain Sorghum-Wheat Rotations</u>	
GWCTB	\$0.00
GWCT1	-\$4.23
GWCT2	\$4.21
GWNTB	\$8.79
GWNT1	\$17.22
