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

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Abstract

This paper examines water quality indices and net returns for conservation tillage and no-till wheat-fallow rotations. Adopting no-till had a small and inconsistent impact on soil erosion and surface runoff across soil types. In contrast, adopting no-till had a significant positive impact on N transport and P transport for each soil type. Net return per acre was similar for the conservation tillage and no-till rotations.

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 Upper 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 Edwards and Ford counties; Richfield in Finney and Hamilton counties; Spearville in Graham county; and Wymore in Kiowa 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 wheat-fallow rotation. Separate net return budgets were developed for conservation tillage and no-till practices. Gross returns were derived using KSU Farm Management Guides for western 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 western 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 1-2. 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 1-2 because this information is required for the EPIC model.

Table 3 contains the crop rotation abbreviations used in the discussion below. Alternative #1 for the conservation tillage and no-till rotations broadcasted nitrogen instead of knifing anhydrous ammonia. The wheat-fallow conservation tillage base rotation was used to make water quality parameter and net return comparisons across rotations.

Water Quality Indices

Water quality indices for soil erosion and surface runoff are presented in Table 4 and Table 5, respectively. The impact of broadcasting nitrogen and adopting no-till practices was inconsistent across soil types. Adopting no-till had a positive impact on soil erosion for Spearville soil in Graham county, and surface runoff for Harney soil in Edwards and Ford counties. Adopting no-till and broadcasting N had a positive impact on soil erosion and surface runoff for every soil type except Spearville in Graham county and Wymore in Kiowa county.

The N transport and P transport water quality indices are reported in Table 5 and Table 6, respectively. The results for these two measures are quite similar. A significant improvement in N transport and P transport was obtained by adopting no-till practices. Using the base conservation and no-till rotations, the improvement in N transport ranged from 37.6% for Spearville soil in Graham county to 45.9% for Richfield soil in Hamilton

county. The improvement in P transport ranged from 32.3% for Spearville soil in Graham county to 44.4% for Wymore soil in Kiowa county.

Net Return Budgets

Cost comparisons among crop rotations can be found in Table 8, Table 9, and Table 10. Table 8 reports the budget for the wheat-fall conservation tillage base rotation. Table 9 reports the budget for wheat-fallow no-till base rotation. Table 10 reports the estimated cost differences between the rotations. In Table 10, the wheat-fallow conservation tillage base rotation is used to compare cost differences among the rotations. A positive number in Table 10 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 10, broadcasting nitrogen adds $3.48 per acre to costs. Adopting no-till practices reduces costs by an estimated $3.02 per acre. The production cost and 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 wheat-fallow rotations considered in this study (Table 10). 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 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.

References

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Table 1. Field Operations for Wheat-Fallow Conservation Tillage Rotation.

Wheat: Base Case	
Tandem disk	1-Aug
Field cultivate	30-Aug
Fertilizer application	15-Sep
Plant wheat	15-Sep
Herbicide application	15-Feb
Harvest wheat	1-Jul
Fallow: Base Case	
Undercut	15-Jul
Herbicide application	1-Aug
Tandem disk	15-May
Alternative #1	
Broadcast nitrogen instead of knifing anhydrous ammonia.	

Table 2. Field Operations for Wheat-Fallow No-Till Rotation.

Wheat: Base Case	
Fertilizer application	15-Sep
Plant wheat	15-Sep
Herbicide application	15-Feb
Harvest wheat	1-Jul
Fallow: Base Case	
Herbicide application	15-Jul
Herbicide application	1-Aug
Herbicide application	1-Apr
Alternative #1	
Broadcast nitrogen instead of knifing anhydrous ammonia.	

Table 3. Crop Rotation Abbreviations.

WFCTB	Wheat-Fallow Conservation Tillage Base Rotation
WFCT1	Wheat-Fallow Conservation Tillage Alternative #1
WFNTB	Wheat-Fallow No-Till Base Rotation
WFNT1	Wheat-Fallow No-Till Alternative #1

Table 4. Soil Erosion Indices for Wheat-Fallow Rotations.

County Soil Type	ED Harney	FI Richfield	FO Harney	GR Spearville	HA Richfield	KI Wymore
WFCTB	1.000	1.000	1.000	1.000	1.000	1.000
WFCT1	1.013	1.024	1.014	1.014	1.014	1.032
WFNTB	1.003	1.056	1.003	0.964	1.062	1.014
WFNT1	0.924	0.962	0.924	0.896	0.963	0.993

County Abbreviations:

ED = Edwards
FI = Finney
FO = Ford
GR = Graham
HA = Hamilton
KI = Kiowa

Table 5. Surface Runoff Indices for Wheat-Fallow Rotations.

County Soil Type	ED Harney	FI Richfield	FO Harney	GR Spearville	HA Richfield	KI Wymore
WFCTB	1.000	1.000	1.000	1.000	1.000	1.000
WFCT1	0.993	0.991	0.993	1.000	0.989	1.042
WFNTB	0.911	1.029	0.912	1.025	1.027	1.076
WFNT1	0.917	0.988	0.917	1.027	0.975	1.022

County Abbreviations:

ED = Edwards
FI = Finney
FO = Ford
GR = Graham
HA = Hamilton
KI = Kiowa

Table 6. N Transport Indices for Wheat-Fallow Rotations.

County Soil Type	ED Harney	FI Richfield	FO Harney	GR Spearville	HA Richfield	KI Wymore
WFCTB	1.000	1.000	1.000	1.000	1.000	1.000
WFCT1	0.994	0.987	0.995	0.991	0.986	0.978
WFNTB	0.560	0.556	0.560	0.624	0.541	0.565
WFNT1	0.490	0.461	0.490	0.497	0.448	0.508

County Abbreviations:

ED = Edwards
FI = Finney
FO = Ford
GR = Graham
HA = Hamilton
KI = Kiowa

Table 7. P Transport Indices for Wheat-Fallow Rotations.

County Soil Type	ED Harney	FI Richfield	FO Harney	GR Spearville	HA Richfield	KI Wymore
WFCTB	1.000	1.000	1.000	1.000	1.000	1.000
WFCT1	1.006	1.017	1.007	1.007	1.015	1.002
WFNTB	0.620	0.606	0.620	0.677	0.591	0.556
WFNT1	0.521	0.498	0.521	0.513	0.486	0.492

County Abbreviations:

ED = Edwards
FI = Finney
FO = Ford
GR = Graham
HA = Hamilton
KI = Kiowa

Table 8. Cost-Return Budget for the Wheat-Fallow Conservation Tillage Base Rotation.

	Wheat	Fallow	Rotation
INCOME PER ACRE			
Yield per Acre	40	0	
Price per Bushel	3.11	0.00	
Net Government Payments	17.85	0.00	
Indemnity Payments	0.00	0.00	
Miscellaneous Income	0.00	0.00	
Returns/Acre	$142.25	$0.00	$71.13
COSTS PER ACRE			
Seed	5.20	0.00	
Herbicide	6.49	2.40	
Insecticide/Fungicide	0.00	0.00	
Fertilizer and Lime	20.65	0.00	
Crop Consulting	0.00	0.00	
Crop Insurance	0.00	0.00	
Drying	0.00	0.00	
Field Operations	58.06	18.09	
Non-Machinery Labor	9.22	0.00	
Miscellaneous	5.50	0.00	
Sub-Total	$105.12	$20.49	$62.80
Interest	4.20	0.82	2.51
Total Costs Excluding Land Charge	$109.32	$21.31	$65.32
RETURNS TO LAND AND MANAGEMENT	$32.93	-$21.31	$5.81

Table 9. Cost-Return Budget for the Wheat-Fallow No-Till Base Rotation.

	Wheat	Fallow	Rotation
INCOME PER ACRE			
Yield per Acre	40	0	
Price per Bushel	3.11	0.00	
Net Government Payments	17.85	0.00	
Indemnity Payments	0.00	0.00	
Miscellaneous Income	0.00	0.00	
Returns/Acre	$142.25	$0.00	$71.13
COSTS PER ACRE			
Seed	5.20	0.00	
Herbicide	6.49	13.51	
Insecticide/Fungicide	0.00	0.00	
Fertilizer and Lime	20.65	0.00	
Crop Consulting	0.00	0.00	
Crop Insurance	0.00	0.00	
Drying	0.00	0.00	
Field Operations	46.45	12.78	
Non-Machinery Labor	9.22	0.00	
Miscellaneous	5.50	0.00	
Sub-Total	$93.51	$26.29	$59.90
Interest	3.74	1.05	2.40
Total Costs Excluding Land Charge	$97.25	$27.34	$62.29
RETURNS TO LAND AND MANAGEMENT	$45.00	-$27.34	$8.83

Table 10. Estimated Cost Differences Between Wheat-Fallow Rotations.

	Change in Cost
WFCTB	$0.00
WFCT1	$3.48
WFNTB	-$3.02
WFNT1	$0.46