

## **Economics of Poultry Litter Use on Cut Rice Fields**

*K.B. Young, H.L. Goodwin, and E.J. Wailes*

### **ABSTRACT**

The economic value of poultry litter on cut rice land is estimated for a study on proposed export of surplus poultry litter to eastern Arkansas. The estimated value of litter on cut rice land ranges up to \$127/ton on deep cut land and up to \$102/ton on shallow cut land. The probable supply cost including spreading and incorporation when trucked from northwest Arkansas is about \$40/ton. Local raw litter in eastern Arkansas has a transport cost advantage of \$16 to \$17/ton. The litter value for fertilizer replacement on rice is only about \$15/ton based on recent research data.

### **INTRODUCTION**

Northwest Arkansas has phosphorus runoff concerns associated with long term application of poultry litter. A feasibility assessment study to evaluate the use of a poultry litter bank for export of surplus litter was initiated in 2003. The goal of this study is to export at least 100,000 tons of excess litter per year to eastern Arkansas and farming areas in Oklahoma, Missouri, and Kansas. Use of poultry litter on cut land is recognized as a high value niche market in eastern Arkansas.

Research on poultry litter use on cut rice soils in Arkansas was conducted about a decade ago (Wilson et al., 1998; Miller et al., 1993). Further research was conducted in 2003 to assess the value of litter as a fertilizer replacement on rice land (Slaton et al., 2004). However, the estimated value of litter for fertilizer replacement is much less than the value on cut ground to restore soil fertility. The major purpose of this paper is to compare the returns of litter use on cut rice land with the fertilizer replacement value of

litter on rice and to evaluate the economics of marketing litter from northwest Arkansas for use on cut rice land in eastern Arkansas.

## **MATERIALS AND METHODS**

The economic return to litter applied on cut ground is assessed by comparing the difference in returns per acre of rice with a recommended chemical fertilizer treatment and a combination of the recommended chemical treatment plus poultry litter. Rice is valued at \$4.75/bu for this analysis. Chemical fertilizer prices are estimated at \$205/ton for P<sub>2</sub>O<sub>5</sub>, \$135/ton for K<sub>2</sub>O, and \$400/ton for Z<sub>n</sub> plus \$4.50/acre spreading cost. Estimated economic returns to litter on cut rice fields are compared with a preliminary estimate of litter supply costs. The market for litter use on cut land is assessed with the use of land leveling estimates for eastern Arkansas counties obtained from the Natural Resources Conservation Service (NRCS).

## **RESULTS AND DISCUSSION**

### **Economic Returns on Cut Land**

Rice yield response data on cut land reported by Wilson et al were tabulated and assessed an economic value based on a rice price of \$4.75/bu (Tables 1 and 2). On deep cut land, rice yielded 60 bu/acre with the recommended chemical fertilizer P and Z<sub>n</sub> treatment, resulting in a return of \$214/acre above the return on the control plot (Table 1). The estimated returns per acre from increased rice production at \$4.75/bu is \$218 with a PKZ<sub>n</sub> treatment plus 1,000 lb litter, \$328 with 2,000 lb litter, \$408 with 4,000 lb litter, and \$385 with the PKZ<sub>n</sub> plus 4,000 lb litter. All other litter/fertilizer combinations provide less return than \$214/acre.

The estimated net return per acre for deep cut rice land from litter application after deducting chemical fertilizer cost is \$127 with 2,000 lb litter and \$207 with 4,000 lb litter (Table 1). The Arkansas Cooperative Extension Service (CES) recommends 2,000 lb litter/acre application on deep cut land.

On shallow cut rice land, the PZ<sub>n</sub> treatment increases rice yield from 73 on the control plot to 105 bu providing an increased value per acre of \$152 (Table 2). Other returns per acre with different combinations of chemical fertilizer and litter are \$157 with PKZ<sub>n</sub> plus 500 lb litter, \$190 with 1,000 lb litter and no PKZ<sub>n</sub>, \$190 with the PKZ<sub>n</sub> plus 1,000 lb litter, \$233 with 2,000 lb litter and no PKZ<sub>n</sub>, \$200 with 4,000 lb litter and no PKZ<sub>n</sub>, and \$204 with the PKZ<sub>n</sub> plus 4,000 lb litter. The estimated maximum net return per acre obtained above the PZ<sub>n</sub> treatment is \$94 with 2,000 lb litter. The Arkansas CES recommends an application of 1,000 lb litter per acre on shallow cut land.

Research conducted by Slaton et al. (2004) on litter use to replace conventional fertilizer use at three research locations in eastern Arkansas estimated that rice yield per acre is less with litter compared with urea on non cut rice land. The N from litter was poorly utilized in this research because the litter was incorporated prior to rice seeding

over six weeks prior to the flood stage for rice. The estimated replacement value of litter to substitute for urea N is only about \$5/ton of litter according to this experiment. The value of P and K is only about \$10/ton of litter. Rice yield was reduced with this litter experiment because of nitrogen deficiency.

The estimated market for litter on cut land in eastern Arkansas is estimated at 72,971 to 77,321 acres excluding Mississippi and Cross Counties (Table 2). Only 20% or less cropland has been leveled so far in most eastern Arkansas counties. Thus, the cut land market in eastern Arkansas could provide an important outlet for poultry litter from northwest Arkansas.

### **Economics of Litter Supply in Eastern Arkansas**

At least some raw poultry litter is currently available in eastern Arkansas for a price range of \$10 to \$20/ton picked up near Pine Bluff, Star City and Batesville. Subsidized poultry litter pellets are currently imported from Delaware and are spread on demand by local fertilizer dealers for about \$110/ton plus about \$3/acre for spreading. Unity™ dried sewage sludge with a guaranteed analysis of 16.6 N, 0.5 P, and 19.0 S is also supplied by fertilizer dealers and used as a soil amendment on cut land. This organized dealer support system in eastern Arkansas for litter pellets and sewage granules is a great convenience for crop producers and up to 1,000 acres of pellets at 300 lb/acre can be spread per day compared with possibly covering 100 acres per day spreading raw litter. Dealers refuse to handle raw litter. Raw litter spreading is especially difficult to manage in spring because of the limited time window for planting crops.

Approximate supply costs for raw litter from northwest Arkansas to eastern Arkansas are expected to be about \$40/ton including spreading and incorporation of the litter if there are no subsidies or load back haul opportunities. This rough estimate includes \$6/ton for house cleanout and loading, \$20/ton for trucking, \$7/ton for spreading, and \$5/ton for incorporation after spreading as recommended by the Arkansas CES. Local raw litter in eastern Arkansas can be supplied for \$16 to \$17/ton less trucking cost. Although the litter value on cut rice land exceeds the supply cost from northwest Arkansas, it is difficult to compete with local litter because of the high transport cost. Even the cheaper local raw litter would not likely be profitable to use as a rice fertilizer replacement according to research reported by Slaton et al. (2004).

### **SIGNIFICANCE OF FINDINGS**

Research evidence is clear from former studies in Arkansas that litter application can return over \$100/ton on deep cut rice land and up to \$102/ton on shallow cut rice land. However, the return is reported to be poor from research conducted so far on litter use as a *replacement* for urea on non cut rice land. Raw litter imported from northwest Arkansas will likely cost up to \$40/ton including spreading and incorporation in the

field. Local raw litter has a \$16 to \$17/ton transport cost advantage. Processed poultry litter pellets and nutrient enhanced dried sewage sludge have a cost over \$100/ton but these products can be spread on demand by fertilizer dealers. Dealers do not like to handle raw litter and there may be problems in finding custom operators to spread raw litter in some areas of eastern Arkansas. Data from NRCS indicated there are over 70,000 acres of land being leveled each year in eastern Arkansas which is an important market for poultry litter.

### **ACKNOWLEDGMENTS**

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**Table 1. Rice yield response/acre to broiler litter (BL) on deep cut (4 to 6 ft) land in Arkansas.<sup>z</sup>**

BL/Fertilizer application	Bushels/Acre	Increase in value <sup>y</sup>	PKZ cost <sup>x</sup>	Residual value	BL Net Return <sup>w</sup>	
					Per acre	Per ton of BL
----- (\$) -----						
Control	15	-	-	-	-	-
PZ <sub>n</sub> <sup>v</sup>	60	214	13	201	-	-
250 BL	28	62	-	62	(139)	(1,112)
250 BL+ PKZ <sub>n</sub> <sup>u</sup>	45	142	18	124	(77)	(616)
500 BL	32	81	-	81	(120)	(480)
500 BL+PKZ <sub>n</sub> <sup>u</sup>	56	195	18	177	(24)	(96)
1,000 BL	54	185	-	185	(16)	(32)
1,000 + PKZ <sub>n</sub> <sup>u</sup>	61	218	18	200	(1)	(2)
2,000 BL	84	328	-	328	127	127
4,000 BL	101	408	-	408	207	104
4,000 BL+PKZ <sub>n</sub> <sup>u</sup>	96	385	18	367	166	83

<sup>z</sup> Source: Wilson, C.E. et al. 1998. Use of Poultry Litter on Rice Soils.

<sup>y</sup> Rice price of \$4.75/bu.

<sup>x</sup> P<sub>2</sub>O<sub>5</sub> at \$205/ton; K<sub>2</sub>O at \$135/ton; Z<sub>n</sub> at \$400/ton plus \$4.50/acre spreading cost.

<sup>w</sup> Gross BL return per ton less return with P+Z<sub>n</sub> treatment

<sup>v</sup> Z<sub>n</sub> = 10 lb Z<sub>n</sub>/acre as Z<sub>n</sub>SO<sub>4</sub>; P = 46 lb P<sub>2</sub>O<sub>5</sub>/acre.

<sup>u</sup> PKZ<sub>n</sub> includes 80 lb K<sub>2</sub>O/acre + P+Z<sub>n</sub>.

**Table 2. Rice yield response/acre to broiler litter (BL) on shallow cut (4 to 6 in.) land in Arkansas.<sup>z</sup>**

BL/Fertilizer application	Bushels/Acre	Increase in value <sup>y</sup>	PKZ cost <sup>x</sup>	Residual value	BL Net Return <sup>w</sup>	
					Per acre	Per ton of BL
----- (\$) -----						
Control	73	-	-	-	-	-
P+Z <sub>n</sub> <sup>v</sup>	105	\$152	\$13	\$139	-	-
250 BL	101	133	-	133	(\$6)	(\$48)
250BL +PKZ <sub>n</sub> <sup>u</sup>	105	152	18	134	(5)	(40)
500 BL	92	90	-	90	(49)	(196)
500BL +PKZ <sub>n</sub> <sup>u</sup>	106	157	18	139	0	0
1,000 BL	113	190	-	190	51	102
1,000 BL +PKZ <sub>n</sub> <sup>u</sup>	113	190	18	172	33	66
2,000 BL	122	233	-	233	94	94
4,000 BL	125	200	-	200	61	30
4,000 BL +PKZ <sub>n</sub> <sup>u</sup>	126	204	18	186	47	24

<sup>z</sup> Source: Wilson, C.E. et al. 1998. Use of Poultry Litter on Rice Soils.

<sup>y</sup> Rice price of \$4.75/bu.

<sup>x</sup> P<sub>2</sub>O<sub>5</sub> at \$205/ton; K<sub>2</sub>O at \$135/ton; Z<sub>n</sub> at \$400/ton plus \$4.50/acre spreading cost.

<sup>w</sup> Gross BL return per ton less return with P+Z<sub>n</sub> treatment

<sup>v</sup> Z<sub>n</sub> = 10 lb Z<sub>n</sub>/acre as Z<sub>n</sub>SO<sub>4</sub>; P = 46 lb P<sub>2</sub>O<sub>5</sub>/acre.

<sup>u</sup> PKZ<sub>n</sub> includes 80 lb K<sub>2</sub>O/acre + P+Z<sub>n</sub>.

**Table 3. Assessment of land leveling in eastern Arkansas, 2004.<sup>z</sup>**

County	Acres of cropland leveled each year	Percent of county cropland already leveled
	(acres)	(%)
Arkansas	1,000	10
Ashley	2,000	25
Chicot	3,000	60
Clay	1,500	65
Craighead	3,500	40
Crittenden	2000-2500	20
Cross	na	na
Desha	±3000	30
Drew	500	34
Greene	1,000	45
Independence	500	9
Jackson	3,500	50
Jefferson	3,500	25
Lawrence	4,000	60
Lee	2,600	15
Lincoln	1,500	65
Lonoke	4000-5000	20
Mississippi	na	na
Monroe	1,000	8
Phillips	3,200	15-20
Poinsett	1,200	12
Prairie	150-200	40
Pulaski	863	37
Randolph	1,500	92
St. Francis	12,000-15,000	10
White	1,000	40
Woodruff	12,760	5
Total	70,773 - 75,323	

<sup>z</sup> Source: NRCS, March 2004.

**Economics of On-farm Reservoirs  
and Other Water Conservation  
Improvements on Arkansas Rice Farms**

*E.J. Wailes, J.Popp, K.B. Young, and J. Smartt*

**ABSTRACT**

The Modified Arkansas Off-Stream Reservoir Analysis (MARORA) model estimates the economics of on-farm reservoirs and other water conservation improvements in alternative ground water situations. With restricted ground water supply, a combination of different water conservation methods is estimated to provide the greatest economic return. On-farm reservoirs are not economical if ground water is adequate but underground pipe and land leveling increase income.

**INTRODUCTION**

The list of critical ground water counties in eastern Arkansas continues to increase over time. Without a major surface water diversion program to replace ground water use, the capture of rainfall and other runoff in on-farm reservoirs will likely become the only alternative for a farmer to sustain irrigation. New investment in on-farm reservoirs/tail-water recovery systems and other water conservation improvements has been encouraged with cost share assistance in the Grand Prairie project, EQIP funding and state income tax benefits. The major purpose of this study is to estimate the impact on net farm income and on water use per acre of water conservation improvements including a reservoir/tail-water recovery system, underground pipe, land leveling, and combinations of two or more of these improvements in alternative ground water situation.

## **PROCEDURES**

The MARORA model is a simulation model developed at the University of Arkansas to estimate the optimal on-farm reservoir/tail-water recovery system that will maximize the net return to land (Young et al., 1998; Wailes et al., 2000, 2002). Other water conservation improvements such as underground pipe and land leveling are evaluated in MARORA in terms of their effect on irrigation efficiency (Smartt et al., 2002). MARORA has been validated for representative Arkansas rice-soybean farms (Wailes et al., 2000; Hill, 2002).

Farm situation assumptions for the application of MARORA included: 1) two alternative ground water situations – relatively adequate with 50-ft initial saturated thickness and 0.5-ft annual decline – compared with relatively inadequate with 30-ft initial saturated thickness and 1.0-ft annual decline; 2) a 320-acre cultivated area; 3) a 1:1 rice-soybean rotation; 4) a rice yield of 160 bu/acre and a soybean yield of 50 bu/acre with yield increased 10% after land leveling; 5) a baseline irrigation efficiency of 50% for rice and 45% for soybeans; 6) efficiency increased 10% with underground pipe; 7) efficiency increased 10% with moderate-efficiency land leveling and 20% with high-efficiency land leveling; and 8) crop prices of \$4.75/bu for rice and \$5.80/bu for soybeans. Other key assumptions are shown in Table 1.

MARORA is used to estimate the Net Present Value (NPV) of net returns per acre on the 320-acre tract over a 30-year period of projection. The estimated increase in net returns attributable to use of a water conservation improvement is compared with the cost of the improvement to calculate a benefit/cost ratio. The effect of underground pipe and land leveling on irrigation efficiency is assumed to be additive when both of these improvements are used together.

Net returns to land are calculated by MARORA by deducting all fixed and variable costs of production from the gross crop income. Crop production costs are derived from Arkansas Cooperative Extension Service budgets. The baseline irrigation efficiency and increased efficiency with underground pipe and land leveling was estimated by Tacker (personal communication). Land leveling is estimated to increase crop yield by 10% to 15% (Scardaci, personal communication; Salassi, 2001). Reservoir, well, and irrigation cost data are derived from NRCS and local contractor estimates.

## **RESULTS AND DISCUSSION**

In the relatively adequate ground water situation, MARORA estimated that an on-farm reservoir is not economical as it is not necessary to sustain irrigation and it would occupy valuable crop land over the projection period (Table 2). Underground pipe is estimated to increase the NPV of returns per acre by \$103 and land leveling \$608 to \$681 in the relatively adequate ground water situation. Total NPV of net returns to land ranges from \$2,516 to \$3,300/acre.

In the relatively inadequate ground water situation, the ground water is quickly depleted. An on-farm reservoir of 620 acre-ft optimal size is required to sustain irrigation and the baseline irrigation efficiency level (Table 2). Estimated NPV of net returns

to land is \$2,312 with a reservoir in this case compared with only \$283 without a reservoir. The \$283 per acre is the estimated return with dryland soybeans.

The combination of a reservoir/tail-water recovery system plus other water conservation improvements increases the NPV of net returns to land in the relatively inadequate ground water situation (Table 2). Underground pipe adds \$144/acre and land leveling adds \$535 to \$674/acre.

Table 3 shows a benefit/cost analysis of the water conservation improvements in the two ground water situations. In the relatively adequate ground water situation, a reservoir is not economic, thus there is no benefit from a reservoir. Underground pipe has a B/C ratio of 1.1. Underground and leveling have a B/C ratio of 1.8 to 2.0 indicating the benefit is about twice the estimated cost per acre.

In the relatively inadequate ground water situation, a reservoir/tailwater recovery system is estimated to have a 4.1 ratio (Table 3). The B/C ratio is 3.9 for the reservoir plus underground pipe, and 3.5 to 3.7 for the combination of reservoir, underground pipe, and land leveling. The water conservation improvements are all estimated to be profitable. Underground pipe returns \$144/acre and costs \$94/acre. Land leveling returns \$535 to \$674/acre and costs \$300/acre. The use of other water conservation improvements reduces the required reservoir capacity to sustain irrigation in the relatively inadequate ground water situation. Thus, the reservoir investment cost and loss of crop land to reservoir construction are reduced when other water conservation improvements are used to increase irrigation efficiency.

A 320-acre tract would on average only supply enough rainfall runoff to fill a 440 acre-ft reservoir assuming 18 in. of average annual rainfall runoff and 80% recovery rate. Runoff from other land would be necessary to fill a large reservoir. Dependence on rainfall runoff may cause farm income to be more variable compared with ground water use due to the annual variability of rainfall in eastern Arkansas.

The estimated NPV of net returns per acre averaged about \$200 less with all improvements used in the relatively inadequate ground water situation (Table 3). The increased cost with a reservoir is due to the higher investment cost per acre compared with irrigation wells and the loss of crop land to reservoir construction.

Results generated with MARORA may differ from actual land prices because of other factors that affect land value beside the rice and soybean income. Typical rice-soybean land in the Stuttgart area is priced around \$2,000 to \$2,500/acre (Jacobs Realty, January 2004, personal communication). Sales data are not available to evaluate the contribution of reservoirs, underground pipe, and land leveling to land selling prices as apparently there has been little turnover of land with recent major water conservation improvements in eastern Arkansas.

## **SIGNIFICANCE OF FINDINGS**

On-farm reservoirs/tail-water recovery systems are estimated to be not economical in relatively adequate ground water situations without any cost share. Underground pipe and land leveling are estimated to be economical in most ground water

situations. On-farm rainfall runoff may not be sufficient to fill reservoirs larger than 440 acre-ft on a 320-acre land parcel. Thus, other water conservation improvements to achieve a higher irrigation efficiency are likely to be necessary with dependency on rainfall runoff to sustain irrigation with a 1:1 rice-soybean rotation. Farms dependent on the use of on-farm reservoirs/tail-water recovery systems will likely experience reduced net returns to land and increased variability on income compared with farms with adequate ground water irrigation.

## **ACKNOWLEDGMENTS**

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**Table 1. List of assumptions for estimating NPV of net returns to land.**

Item	Assumptions <sup>z</sup>
Baseline model	Irrigation efficiency of 45% for soybeans and 50% for rice
Reservoir/tail-water system	Captures 80% of tail-water with a 30-year projected life
Wells	\$14,000 with 1200GPM, 30-years life, 3 wells on 320 acres
Well pumps	\$14,000 with 15-year life
NPV of income	discounted at 8% for 30 years
Relatively adequate ground water	50 feet initial saturated thickness and 0.5 foot annual decline rate
Relatively inadequate ground water	30 feet initial saturated thickness and 1.0 foot annual decline rate
Underground pipe	buried \$94/acre; increases irrigation efficiency 10% above baseline
Land leveling	\$300/acre; increases irrigation efficiency by 10 to 20% above baseline
Crop prices	Rice \$4.75/bu, soybeans \$5.80/bu; based on loan rate plus direct plus counter-cyclical pay
Crop yields	Rice 160 bu/acre, soybeans 50 bu/acre; yields increase 10% with land leveling
Crop rotation	1:1 rice-soybeans
Crop production costs	2003 Arkansas CES budgets
Rainfall data	Stuttgart, Arkansas
Reservoir cost	\$1/cubic yard excavation plus one-time \$700/acre levee seeding
Land area	320 acres, less land used for reservoir/tail water system

<sup>z</sup> The assumptions are representative of conditions on rice-soybean farms in eastern Arkansas. Other assumptions and data sources are reported by Smartt et al., 2002.

**Table 2. Estimated NPV of net returns to land with water conservation improvements.**

Ground water situation/ conservation improvement	Irrigation efficiency		Optimal reservoir size	Cultivated acres		Water use		NPV per acre (\$/acre)
	Rice	Soybeans		Rice	Soybeans	Rice	Soybeans	
	----- (%) -----		(acre-feet)	----- (acres) -----		----- (in.) -----		
<b>Relatively adequate ground water situation<sup>z</sup></b>								
Baseline (no reservoir)	50	45	0	160	160	40.0	26.2	2,516
Baseline (optimal reservoir)	50	45	0	160	160	40.0	26.2	2,516
Underground pipe (no reservoir)	60	55	0	160	160	33.5	21.6	2,619
Underground pipe plus leveling with moderate efficiency	70	65	0	160	160	28.8	18.4	3,227
Underground pipe plus leveling with high efficiency	80	75	0	160	160	25.2	16.1	3,300
<b>Relatively inadequate ground water situation<sup>y,x</sup></b>								
Baseline (no reservoir)	50	45	0	0	320	0.0	0.0	283
Baseline (optimal reservoir)	50	45	620	127	127	39.7	26.7	2,312
Underground pipe (optimal reservoir)	60	55	520	132	132	33.1	22.0	2,456
Underground pipe plus leveling with moderate efficiency	70	65	440	136	136	28.4	18.5	2,625
Underground pipe plus leveling with high efficiency	80	75	400	138	138	24.8	16.6	3,130

<sup>z</sup> Situation with 50 feet initial saturated thickness and 0.5 foot annual decline rate.

<sup>y</sup> Situation with 30 feet initial saturated thickness and 0.5 foot annual decline rate.

<sup>x</sup> A reservoir/tailwater recovery system is not profitable for the relatively adequate ground water situation.

**Table 3. Estimated cost and increased NPV of net returns to land with water conservation improvements.**

Ground water situation/ conservation improvement	Irrigation efficiency		Optimal reservoir size (acre-feet)	Investment cost	NPV per acre baseline	Change in NPV per acre from improvement	Benefit/cost ratio for improvement
	Rice	Soybeans					
	----- (%) -----		----- (\$) -----				
<b>Relatively adequate ground water situation<sup>y</sup></b>							
Baseline (no reservoir)	50	45	0	0	2,516	0	
Underground pipe (no reservoir)	60	55	0	94	2,619	103	1.1
Underground pipe plus leveling with moderate efficiency	70	65	0	394	3,227	711	1.8
Underground pipe plus leveling with high efficiency	80	75	0	394	3,300	681	2.0
<b>Relatively inadequate ground water situation<sup>x,w</sup></b>							
Baseline (no reservoir)	50	45	0	0	283	0	
Baseline (optimal reservoir)	50	45	620	496	2,312	2,029	4.1
Underground pipe (optimal reservoir)	60	55	520	556	2,456	2,173	3.9
Underground pipe plus leveling with moderate efficiency	70	65	440	781	2,991	2,708	3.5
Underground pipe plus leveling with high efficiency	80	75	400	769	3,310	2,847	3.7

<sup>z</sup> Ratio of change in NPV of net returns to land per acre from baseline NPV and investment cost per acre for improvements.

<sup>y</sup> Situation with 50 feet initial saturated thickness and 0.5 foot annual decline rate.

<sup>x</sup> Situation with 30 feet initial saturated thickness and 0.5 foot annual decline rate.

<sup>w</sup> A reservoir/tailwater recovery system is not profitable for the relatively adequate ground water situation.

## **Implications of the World Trade Organization's Doha Round for the Rice Sector**

*E.J. Wailes*

### **ABSTRACT**

The objective of this study is to measure the effect of global policy reforms on rice trade, prices, and economic welfare. The Doha Round of multilateral trade negotiations aims to increase market access, and reduce or eliminate export subsidies and trade distorting domestic price supports. Two modeling frameworks are used to estimate trade, price and economic welfare effects of policy reforms. World rice trade is estimated to expand by 15%, export prices increase by 33%, and import prices are reduced by 14%. Global economic welfare improves by \$7.4 billion annually and the United States gains nearly \$900 million annually.

### **INTRODUCTION**

The Uruguay Round Agreement on Agriculture represented a turning point in the history of the multilateral trading system by subjecting agricultural trade to essentially the same rules that discipline trade in industrial goods. However, with the signing of the Doha Ministerial Declaration in November 2001, objectives and deadlines for the current round of multilateral negotiations have not been met. Little compromise has been reached on core issues regarding commitments to further expand market access, reduce or eliminate export subsidies, and lower trade-distorting domestic supports.

Through the 1990s trade liberalization has had a positive impact on the international rice market because rice trade has been highly protected in both industrialized and developing nations. The relatively modest terms of agreement in the Uruguay Round Agreement on Agriculture along with regional trade agreements and national

policy reforms have contributed to a doubling in global rice trade in the latter half of the 1990s (Fig. 1). Nevertheless, rice remains with sugar and dairy products, as one of the most protected food commodities in world trade.

The major types of distortion in world rice markets are import tariffs and tariff rate quotas (TRQs) in key importing countries and price supports in key exporting countries. In 2000, the global trade weighted average tariff on all rice was 43.3%. Medium-grain rice markets are far more distorted than long-grain rice markets due to the TRQs and quotas in the major medium-grain rice importing countries of Japan, South Korea, and Taiwan. Global trade weighted average rice tariffs in 2000 for medium- and short-grain rice markets were 217% compared to 21% for the long-grain market. In addition to trade protection by rice type, an important dimension of world rice trade is protection for the domestic rice milling industry. This form of protection is expressed in tariff escalation and is especially prevalent in Central and South American nations and the European Union. Price supports for rice producers have been important in the major industrialized countries or regions including the European Union, Japan, and the United States.

The Doha Round of trade negotiations has moved slowly as countries have been unwilling to compromise on market access, export subsidy, and domestic support proposals. This paper attempts to measure the potential gains from the removal of policy distortions in the global rice economy.

## **PROCEDURES**

Estimates of the impact of the elimination of import tariffs, export subsidies, and domestic supports were generated through the use of two modeling frameworks, a spatial equilibrium model, RICEFLOW (Durand-Morat and Wailes, 2003) and the Arkansas Global Rice model (AGRM), a dynamic econometric framework (Fuller et al., 2003).

For this study, RICEFLOW was disaggregated by rice type and degree of milling and the baseline and estimated impacts apply to trade flows and prices for the year 2000. The AGRM structure is based on equations for supply, expressed in terms of equations that estimate area harvested and yields; and for demand, expressed in equations for domestic consumption, exports, imports, and ending stocks. Rice prices are endogenized, with world reference equilibrium prices for long-grain and medium-grain rice. The effects of domestic price supports and trade policy are captured in the supply and demand framework of AGRM. For this study, policy interventions in rice supply that are trade-distorting (“amber box” in WTO parlance) were removed. To place the impacts of the removal of domestic policies on rice trade in perspective, the model was also simulated for the removal of import tariffs and export subsidies as well. This exercise provides an additional analysis to evaluate the trade impact results generated by RICEFLOW, the spatial equilibrium modeling framework. Finally, the AGRM was used to examine the net effect of complete policy reform including domestic support, import protection and export subsidies.

## **RESULTS**

Using the RICEFLOW model, complete rice trade liberalization in 2000 would have resulted in an expansion in global rice trade of nearly 3.5 mmt, a 15% increase in trade compared to actual 2000 rice trade (Table 1). Trade weighted average export prices would be 32.8% higher and trade weighted import prices would be 13.5% lower. Because of differences in protection by rice type and degree of milling, the results presented reflect that the greatest gains in trade volume and elimination of price distortions are for the medium-grain markets. Trade in medium-/short-grain with trade liberalization would increase by 73%. Producer export prices would rise by 91% and import prices would decline by 27%. Long-grain rice trade liberalization results in a 7% increase in volume traded. Export prices increase by only 2% but import prices fall by 18%, improving consumer welfare in long-grain rice importing nations. Most of the expansion in long-grain trade occurs in the low quality markets such as Indonesia, Bangladesh, and Philippines. Global rice trade liberalization results in a total economic surplus gain of USD 7.4 billion annually. Importing countries, as a group, have a net gain of USD 5.4 billion and exporting nations gain USD 2 billion.

The magnitudes of the net gains vary considerably by country and by rice type and degree of milling. For the United States, the analysis shows that on balance U.S. rice producers would gain more than consumers would lose from higher prices by \$326 million annually. Most of these net gains however would be in medium grain rice markets. Clearly, removal of price supports for the United States rice industry is not rational unless market access for U.S. exports is negotiated in import markets. With already very low import tariffs, the U.S. would lose very little tariff revenue from the elimination of our tariffs. Elimination of price supports would improve the net benefits to the United States overall by nearly \$600 million annually. Therefore the net benefit to the U.S. economy including net gains to producers and reduced price support outlays would exceed \$900 million annually.

Using the dynamic non-spatial global rice trade model AGRM, the removal of import tariffs, export subsidies, and domestic supports are measured by separate scenarios and together. The impact on global rice trade from the removal of tariffs dominates all policy reform scenarios. The combined effect of the removal of tariff barriers, export subsidies, and domestic supports increases trade by 2.4 mmt in 2005 and by 4.9 mmt by 2012 (Fig. 2). Long-grain export prices are higher by 18 to 22%. This result differs from the RICEFLOW model result for export prices. Medium-grain prices are higher than baseline projections by 70 to 80%, a result similar to the findings reported using the RICEFLOW model (Fig. 3).

## **SIGNIFICANCE OF FINDINGS**

Multilateral and regional trade policy reforms achieved over the past decade have contributed to an expansion in rice trade and more stable prices. The achievements of the Uruguay Round Agriculture Agreement include the opening of the previ-

ously closed Japanese and South Korean markets. Limits placed on domestic supports in the EU and the U.S. and export subsidies in the EU have yet to have a significant impact on rice trade. Regional agreements such as NAFTA and MERCOSUR have increased western hemisphere rice trade. The prospects for the Doha Round of the WTO hinge to a great extent upon continuing the expansion of market access, reduction of tariffs, and limits on export subsidies that will be effective. Continued trade policy reforms are important for the global rice economy and will have positive impacts on producers in exporting nations and consumers in importing countries. But reforms will result in losses to other market participants. The exercise of political power by specialized interests in protecting their existing benefits from a policy-distorted global rice sector cannot be underestimated. Therefore it is important to continue efforts to clearly measure and understand the consequences of protection and the benefits of moving forward.

### **ACKNOWLEDGMENTS**

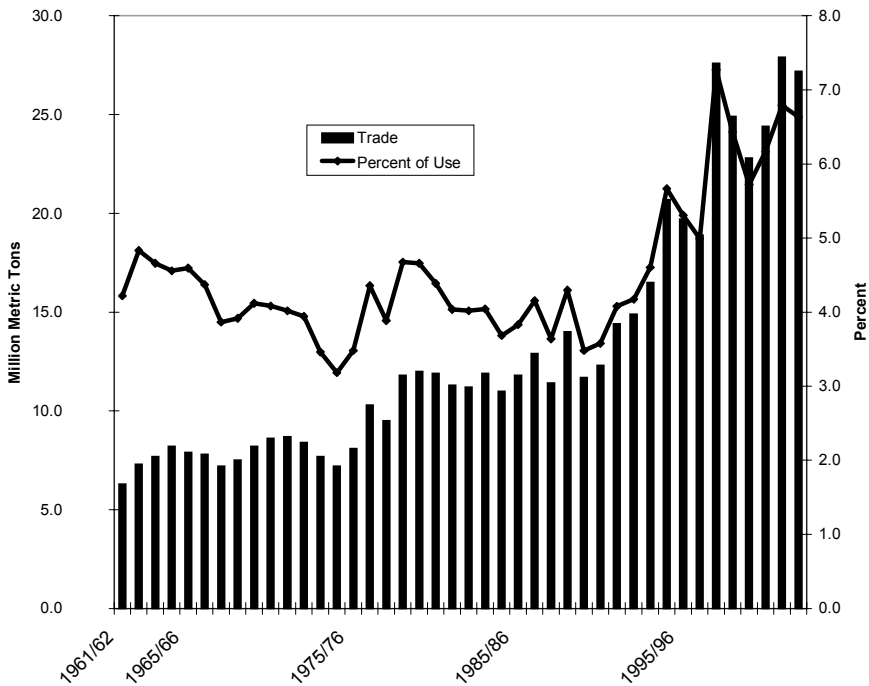
Funding for this study was provided by the USDA, the Arkansas Rice Research and Promotion Board and the World Bank.

### **LITERATURE CITED**

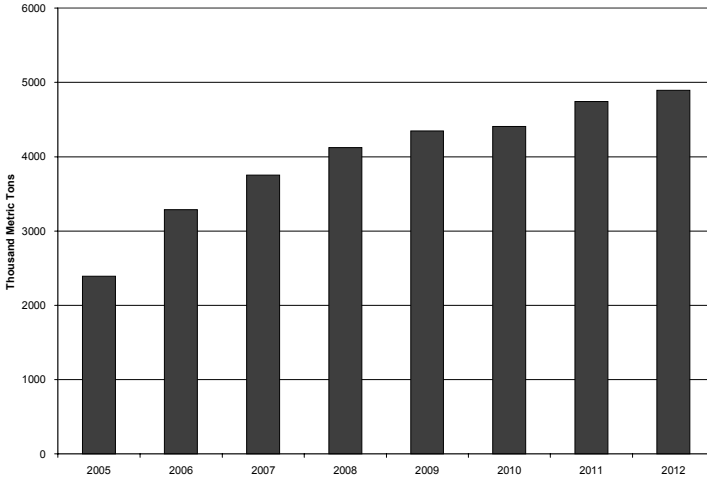
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**Table 1. Rice trade liberalization results from RICEFLOW model, 2000.**

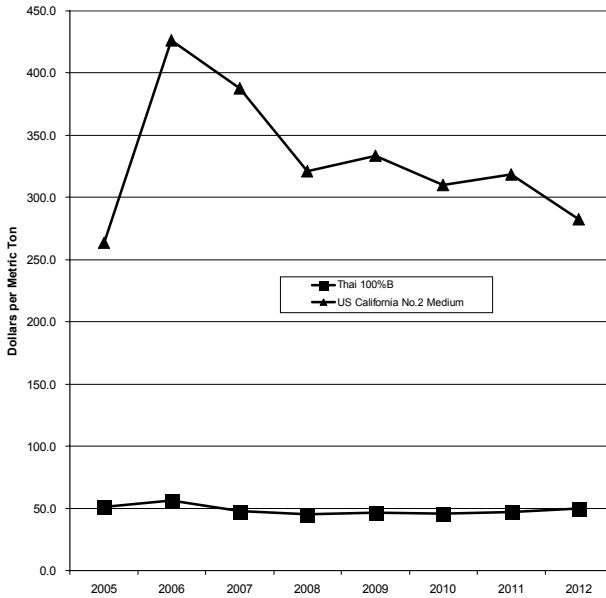
Rice type	Baseline	Free trade	% Change
<b>Long-grain</b>			
Quantity traded (MT)	19,921,516	21,319,687	7.0%
Export price (\$/MT)	206.87	210.68	1.8%
Import price (\$/MT)	287.45	236.43	-17.7%
<b>Medium-/short-grain</b>			
Quantity traded (MT)	2,970,823	5,108,648	72.0%
Export price (\$/MT)	352.11	671.14	90.6%
Import price (\$/MT)	950.63	690.53	-27.4%
<b>All rice</b>			
Quantity traded (MT)	22,892,339	26,428,335	15.4%
Export price (\$/MT)	225.71	299.69	32.8%
Import price (\$/MT)	373.51	322.97	-13.5%



**Fig. 1. World rice trade and share of trade to use, 1961-2002.**



**Fig. 2. Impact on world trade from policy reform using AGRM model, 2005-2012.**



**Fig. 3. Impact on long- and medium-grain rice export prices from policy reform using AGRM model, 2005-2012.**

**Impacts of Alternative Management  
Practices on Rice System  
Profitability in the Arkansas Grand Prairie**

*K.B. Watkins, M.M. Anders, T.E. Windham, J.H. Hill, and J. Marshall*

**ABSTRACT**

This analysis uses data from an ongoing long-term rice-based cropping systems study at the Rice Research and Extension Center, Stuttgart, Ark., to determine how various production components like rotation, tillage, and fertility affect rice system profitability in the Arkansas Grand Prairie region. Crop yields and net returns are compared for twelve production systems differing by rotation (continuous rice; rice-soybean; rice-corn), tillage (conventional till versus no-till), and fertility (standard versus enhanced) for the years 2000 through 2003. The Duncan Multiple Range Test is used to determine significant differences in mean yields and returns across rice system components, and return variability is evaluated using the coefficient of variation. Rice-soybean systems produced the largest average net returns due to lower production costs for soybeans in the cropping sequence, while rice-corn systems were the least profitable due to low corn yields. Enhanced fertility had no significant impact on average crop yields across rice systems, but enhanced fertility did reduce net return variability for continuous rice and rice-soybean systems using conventional till. Crop yields and net returns were smaller on average for no-till than for conventional till rice systems. However, no-till rice-soybean systems exhibited the least return variability, implying strong potential for no-till management in rice-soybean cropping systems.

**INTRODUCTION**

Arkansas rice producers face an uncertain production environment. Low farm prices and high production costs make many rice producers dependent on government

payments to maintain profitability. Rice producers also face declining groundwater availability in many areas of the state and uncertainty about future regulations on sediment transport from fields. This uncertain production environment forces many producers to consider changing their management systems (shifting to different rotations, changing tillage practices, or switching to a different crop mix). However, rice producers are reluctant to try new production systems without information about the costs and returns. This study uses data from a long-term rice-based cropping systems study at the University of Arkansas Rice Research and Extension Center (RREC) near Stuttgart, Ark. (Anders et al., 2000, 2001, 2002, 2003) to determine how various production components like rotation, tillage, and fertility affect rice system profitability in the Arkansas Grand Prairie region.

## **PROCEDURES**

This analysis uses an enterprise budget approach to calculate per acre costs and returns for 12 different rice production systems for the years 2000 through 2003. The rice system components evaluated in the analysis include three rotations (Continuous Rice; Rice-Soybean; Rice-Corn), two tillage practices (Conventional Till; No-Till), and two fertility treatments (Standard; Enhanced). The 12 production systems correspond to rotations 1 through 5 reported in Anders et al. (2001). For more information on the cultivars, rotations, and fertility treatments used in the entire long-term rice-based cropping systems study, see Anders et al. (2001).

Annual enterprise budgets were compiled for each rotation crop using annual crop yield, input, and field operations data from the long-term study. Total specified costs included direct expenses (seeds, fertilizer, pesticide, labor, repairs and maintenance, custom work, and interest on operating capital) and fixed expenses (machinery depreciation and interest) but did not include charges to unpaid labor, overhead capital, land, or management. Annual costs and returns for systems involving two crops (e.g., rice-soybean systems and rice-corn systems) were calculated on a rotation-weighted acre basis (1 acre rice-soybean rotation = 0.5 acre rice + 0.5 acre soybean).

Crop prices were held constant at loan rate values (\$2.99/bu rice; \$5.00/bu soybeans; \$1.98/bu corn), and the Index of Prices Paid by Farmers was used to adjust all annual cost data to 2003 dollars. The Duncan Multiple Range test was used to determine significant differences in mean crop yields and mean returns and costs across rice system components. Net return variability was evaluated for each of the 12 systems over the four-year period using the coefficient of variation (CV).

## **RESULTS AND DISCUSSION**

### **Yield Results**

Duncan Multiple Range Test results of rice system yields by crop and production component are reported in Table 1. Average rice yields were significantly smaller

for continuous rice systems over the 2000 through 2003 period. The lower yields for the continuous rice systems were attributed to poor plant N uptake throughout the growing season (Anders et al., 2003). There was no significant difference in average rice yields between the rice-soybean and the rice-corn systems. Average crop yields were significantly lower under no-till management. However, enhanced fertility had no significant impact on crop yields, implying little if any gain from applying fertilizer above recommended levels.

Average rice and soybean yields were significantly larger in 2000 than in any other experiment year due to high inherent soil fertility in the field resulting from years of fallow prior to the experiment. Average corn yields were generally lower than state average yields throughout the experiment (Arkansas state average corn yield = 137 bu/acre in Table 1). The low corn yields were the result of poor root penetration through the hardpan layer.

### **Economic Results**

Duncan Multiple Range Test results of rice system economics by system component are presented in Table 2. Average gross returns were significantly larger for continuous rice systems due to rice being in the cropping sequence every year. However, rice-soybean systems had the smallest total costs due to the lower production cost of soybeans in the cropping sequence. Thus rice-soybean systems tended to be the most profitable among the 12 systems evaluated. Rice-corn systems were the least profitable due to low corn yields.

Conventional till systems produced the largest gross returns on average due to higher yields relative to no-till systems. Total costs were not significantly different between conventional till and no-till rice systems. Therefore, the no-till rice systems tended to be less profitable than the conventional till systems on average. Enhanced fertility had no significant impact on rice system gross returns, but total costs were significantly greater for enhanced fertility relative to standard fertility. Thus average net returns above total costs were significantly larger for rice systems using standard fertility.

With the exception of 2000, there was no significant difference in rice system gross returns across experiment years. Rice system gross returns were significantly larger in 2000 due to larger rice and soybean yields in that year. Total costs varied little across experiment years with the exception of 2002. Rice system total costs were larger in 2002 due to larger than normal pesticide application costs to control weeds and insects in rice during that year. Weed pressure was especially strong in the no-till rice plots in 2002 because of a breakdown in the herbicide Command. A buildup in organic matter over time reduced the effectiveness of Command. Command rates were adjusted in 2003 to reflect the greater organic matter in the no-till plots.

Net return summary statistics for the 12 rice systems over the 2000 through 2004 period are presented in Table 3. The rice-soybean conventional till system using standard fertility produced the largest average net return above specified costs (\$145/acre;

CV = 48). However, the rice-soybean no-till system using standard fertility exhibited the smallest net return variability in terms of its coefficient of variation (CV = 11; average net return = \$105/acre). The economic statistics also provide some insight into the effect of enhanced fertility on rice system economics. Although enhanced fertility did not appreciably increase average profitability for the 12 cropping systems evaluated, additional applied fertilizer did reduce net return variability in some instances as measured by the CV. Specifically, enhanced fertility reduced the return variability of the continuous rice conventional till system (CV = 30 for enhanced fertility; CV = 41 for standard fertility) and the rice-soybean conventional till system (CV = 33 for enhanced fertility; CV = 48 for standard fertility).

### **SIGNIFICANCE OF FINDINGS**

All production components significantly impact rice system profitability. Rice-soybean rotations appear to be the most profitable systems in the Arkansas Grand Prairie region, primarily because of cost savings resulting from the inclusion of soybeans in the cropping sequence. Applying fertilizer at rates above recommended levels does not appreciably increase profitability but does in some instances reduce return variability. No-till systems tend to be less profitable than conventional till systems in terms of average net returns above specified costs. However, net return variability was smallest for rice-soybean no-till systems, implying strong potential for no-till management in these cropping systems.

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**Table 1. Duncan Multiple Range Test results of rice system yields, Rice Research and Extension Center long-term cropping systems study, 2000 to 2003.**

	Rice	Soybean	Corn
	----- (bu/acre) -----		
<b>Rotation</b>			
Continuous rice	142 b <sup>z</sup>		
Rice-soybean	176 a	44	
Rice-corn	174 a		99
<b>Tillage</b>			
Conventional till	170 a	48 a	117 a
No-till	158 b	40 b	81 b
<b>Fertility</b>			
Standard	164 a	44 a	97 a
Enhanced	165 a	44 a	102 a
<b>Year</b>			
2000	177 a	52 a	75 c
2001	158 c	36 c	106 ab
2002	157 c	44 b	94 b
2003	165 b	45 b	121 a
<b>State average yields</b> (2000 to 2003) <sup>y</sup>	141	38	137

<sup>z</sup> Means within a column followed by different letters are significantly different at the P=0.05 level of confidence.

<sup>y</sup> Arkansas Agricultural Statistics Service, NASS, USDA.

**Table 2. Duncan Multiple Range Test results of rice system economics, Rice Research and Extension Center long-term cropping systems study, 2000 to 2003.**

	Gross returns	Total costs	Net returns
	----- (\$/acre) -----		
<b>Rotation</b>			
Continuous rice	425 a <sup>z</sup>	331 a	94 b
Rice-soybean	373 b	259 c	114 a
Rice-corn	332 c	319 b	13 c
<b>Tillage</b>			
Conventional till	400 a	305 a	95 a
No-till	354 b	301 a	53 b
<b>Fertility</b>			
Standard	373 a	291 b	82 a
Enhanced	380 a	315 a	65 b
<b>Year</b>			
2000	407 a	294 b	113 a
2001	372 b	296 b	76 b
2002	366 b	327 a	39 c
2003	363 b	296 b	67 b

<sup>z</sup> Means within a column followed by different letters are significantly different at the P=0.05 level of confidence.

**Table 3. Rice system net return summary statistics, Rice Research and Extension Center long-term cropping systems study, 2000 to 2003.**

Rotation	Tillage	Fertility	Average	SD	CV	Maximum	Minimum
			--- (\$/acre) ---		(%)	----- (\$/acre) -----	
Continuous rice	CT <sup>z</sup>	S <sup>y</sup>	126	52	41	172	60
Continuous rice	CT	E	109	33	30	157	81
Continuous rice	NT	S	67	63	94	116	-23
Continuous rice	NT	E	74	81	110	142	-42
Rice-soybean	CT	S	145	69	48	224	80
Rice-soybean	CT	E	125	42	33	184	95
Rice-soybean	NT	S	105	12	11	122	96
Rice-soybean	NT	E	80	10	12	89	69
Rice-corn	CT	S	50	50	101	117	4
Rice-corn	CT	E	14	40	286	58	-23
Rice-corn	NT	S	0	45	12269	45	-43
Rice-corn	NT	E	-11	44	-403	39	-55

<sup>z</sup> CT = conventional Till; NT = no-till.

<sup>y</sup> S = standard fertility; E = enhanced fertility.