An Economic Risk Analysis of Tillage and Cropping Systems on the Arkansas Grand Prairie

Jeffrey A. Hignight, K. Bradley Watkins, and Merle M. Anders*

Contact Author:
Jeffrey Hignight
University of Arkansas Rice Research & Extension Center
2900 Hwy. 130 E.
Stuttgart, AR 72160
(870) 673-2661
jhignig@uark.edu

*The authors are, respectively, Program Associate-Economics, Associate Professor-Economics, and Assistant Professor-Agronomy. All are with the University of Arkansas, Division of Agriculture, located at the Rice Research and Extension Center, Stuttgart, AR.

Selected Paper prepared for presentation at the Southern Agricultural Economics Association Annual Meeting, Orlando, FL, February 6-9, 2010

An Economic Risk Analysis of Tillage and Cropping Systems on the Arkansas Grand Prairie

Abstract

No-till (NT) has been shown to reduce fuel, labor, and machinery costs compared to conventional-till (CT) but very few rice producers in Arkansas practice NT. The low adoption rate is most likely due to difficulties in management but also limited information on the profitability and risk of NT. Most rice producers are knowledgeable on NT costs savings but consider it less profitable due to yield reductions offsetting costs savings. This study evaluates production costs, crop yields, and economic risk of both NT and CT in five rice-based cropping systems (continuous rice, rice-soybean, rice-corn, rice-wheat, and rice-wheat-soybean-wheat). Yields, crop prices, and key input prices are simulated to create net return distributions. Stochastic efficiency with respect to a function (SERF) is used to evaluate profitability and risk efficiency. Results indicate that a risk-neutral and risk-averse producer in either NT or CT would prefer a rice-soybean rotation. NT would be preferred over CT in the rice-soybean rotation across all risk preferences. Overall, risk-neutral producers would prefer NT in four of five cropping systems while risk-averse producers would prefer NT in three of five cropping systems.

Key Words: cropping systems, rice, no-till, certainty equivalent, risk premium

An Economic Risk Analysis of Tillage and Cropping Systems on the Arkansas Grand Prairie

Introduction

No-tillage (NT) crop production in the United States has increased in popularity in areas growing corn and soybeans where irrigation is not required and accounts for approximately 22.6% of planted acres (Peterson, 2005). Information collected from no-tillage production areas indicates that converting from conventional-tillage (CT) to NT can improve soil quality through increased organic matter and improved water infiltration (Rachman et al., 2003). In addition, NT can provide social benefits through improved water and air quality.

A study in the southwestern Ohio and southeastern Indiana watersheds indicated that water quality improved in rivers and could be partially attributed to the increased adoption of conservation-tillage (Renwick et al., 2008). A simulated rainfall study in Arkansas indicated that NT reduced soil erosion and runoff water significantly compared to CT (Harper, 2006). Carbon sequestration and reduced carbon dioxide emissions are also social benefits gained from NT. Using a global database, West and Post (2002) concluded that converting from CT to NT sequestered on average 57g C m^{-2} yr^{-1} and intensive rotations could sequester and additional 20g C m^{-2} yr^{-1}. The study also concluded carbon sequestration would reach a new equilibrium between 5 and 10 years while soil organic carbon would reach equilibrium in 15 to 20 years.

Rice is Arkansas' highest valued crop and accounts for nearly half of US total production (USDA). Rice is typically rotated with soybeans although some acres are continuous rice or rotated with other crops such as corn, sorghum, cotton, and wheat. In 2002, NT rice production in Arkansas was estimated at 9% (Wilson and Branson, 2002) and increased to 16% by 2008 (Wilson and Runsick, 2008). No-till has been shown to reduce labor, fuel, and machinery costs

(Epplin et al. 1982 and Krause and Black 1995). Some of these costs savings may be offset by increased herbicide use and lower crop yields. Reductions of these costs should favor the use of NT cropping systems in Arkansas but adoption has lagged the national adoption rate. The lack of adoption may be attributed to potential management issues, fear that grain yields will be significantly less than CT, and limited profit and risk information.

The economics of NT have been investigated throughout the US estimating the mean income for corn and wheat (Burton et al. 2009; Archer et al. 2008; and Al-Kaisi 2004). The studies concluded NT could be an economically viable option for replacing CT. Other studies have investigated the input costs structure and concluded that as fuel becomes more expensive relative to glyphosate the economic benefits of NT increase versus CT (William et al. 2009 and Nail et al. 2007).

Other studies have explored the risk of NT systems compared to CT cropping systems. Archer and Reicosky (2009) determined that risk neutral and risk-adverse corn and soybean producers in the northern Corn Belt would prefer NT to CT. Riberia et al. (2004) examined tillage and five cropping systems in Texas and found that risk-adverse producers would prefer NT in all five cropping systems while risk-neutral producers would prefer NT in four of the five systems.

Partial budget economic studies of flooded or intermittently flooded conditions have been mixed. Pearce et al. (1999) found NT rice to be unprofitable relative to CT on soils with high salinity. Smith and Baltazar (1992) found NT rice to be more profitable on the Arkansas Grand Prairie. Watkins et al. (2004) found NT rice/soybean rotation to be less profitable although Watkins et al. (2008) found that risk-neutral and risk-adverse tenants would favor NT over CT.

One major shortcoming of the rice studies mentioned is that the data sets used were very small. Using a small data set may not represent a clear picture of NT and has resulted in studies concluding different economic results. Another shortfall of some of the studies mentioned is that economic risk is addressed only from the price received perspective. Producers also face input price risk which is typically considered deterministic in simulation analysis. Other studies exclude risk in general and present results solely from a risk-neutral perspective.

The objective of this study is to compare the profitability and risk of NT and CT rice based cropping systems continuously grown or rotated with soybeans, corn, and/or wheat on Arkansas Grand Prairie silt loam soils. The yield data encompasses ten years of test plot experiments from 2000-2009. The paper will examine differences in production costs, crop yields, and economic risk facing Arkansas producers on the Grand Prairie.

Data and Methods

Stochastic Model. Distributions for net returns to tillage and cropping systems were empirically estimated using a stochastic model. The simulation model is represented by the following equation:

$$\mathrm{NR_i} = \sum_{k=1}^{n} (.75 * \tilde{\mathrm{Y}}_{\mathrm{ij}} * \tilde{\mathrm{P}}_{\mathrm{j}} * \mathrm{F_{ij}}) - (((.75 * \tilde{\mathrm{Y}}_{\mathrm{ij}} * \mathrm{V_{1j}}) - (\tilde{\mathrm{Y}}_{\mathrm{ij}} * \mathrm{V_{2j}}) - \tilde{\mathrm{V}}_{3\mathrm{ij}} - \mathrm{V_{4ij}}) * \mathrm{F_{ij}})$$

Where

$\tilde{\mathrm{Y}}_{\mathrm{ij}}$ is stochastic yield of crop j in rotation i
$\tilde{\mathrm{P}}_{\mathrm{j}}$ is the stochastic price for crop j
$\mathrm{F_{ij}}$ is the percent crop j represents in rotation i
$\mathrm{V_{1j}}$ is the per-yield drying cost and checkoff fee of crop j
$\mathrm{V_{2j}}$ is the per-yield hauling costs of crop j
$\tilde{\mathrm{V}}_{3\mathrm{ij}}$ is the stochastic costs of glyphosate, fuel, and fertilizer for crop j in rotation i
$\mathrm{V_{4ij}}$ is the per acre deterministic production costs of crop j in rotation i

The stochastic model contains land costs and is assumed to be 25% of the gross revenues. This crop share rental arrangement is common in Arkansas especially on rice ground (Bierlen and Parsch, 1996). Typically under this crop share arrangement, drying cost is shared at the same proportion of the crop share. Irrigation is typically paid by the tenant who must also provide a power unit for pumping. The landlord typically provides the well, pump, and gearhead.

Crop prices received, fuel, fertilizer, glyphosate, and yields are the stochastic variables in the model. Multivariate empirical (MVE) distributions of the variables were estimated and simulated using the Excel add-in Simetar (Richardson et al., 2008). The MVE distribution creates a distribution of the deviations expressed as a fraction from the mean or trend and simulates the random value based upon the frequency distribution of the actual data. A MVE distribution has been shown to appropriately correlate random variables based upon their historical correlation (Richardson et al., 2000).

Direct and Fixed Expenses. Direct and fixed expenses for crops and tillage were calculated by taking the average of the past three years (2007-2009) using the Mississippi State Budget Generator (Laughlin and Spurlock, 2006). Input quantities used came from the long-term tillage and cropping system study being conducted at the University of Arkansas' Rice Research and Extension Center in Stuttgart, AR. The budgeted production costs are presented in Table 1. Direct expenses include fertilizers, herbicides, irrigation supplies, crop seed, adjuvant, custom hire, labor, fuel, repairs, maintenance, and interest on operating capital. Other costs not included are on a per unit basis. Drying cost is estimated at $0.33 and $0.19/bu for rice and corn, respectively. Soybeans and wheat usually do not need drying and their costs are assumed zero for this analysis. The Arkansas checkoff fee for rice is $0.0135/bu and $0.01/bu of corn, wheat, and soybeans. Hauling cost for all crops is assumed to be $0.20/bu. Fixed expenses are calculated per acre and estimated using the capital replacement method and include tractors, harvesters, irrigation machinery, and implements.

Prices. Crop prices received and key production input prices from the previous ten years were used to create a MVE. Crop prices received are the season average for Arkansas and the key inputs are the national seasonal average (USDA National Agricultural Statistical Service). Prices were detrended using linear regression. The residuals from the regression were used to calculate the historical correlation between price variables, and each variable's frequency distribution of residuals was used to simulate risk in prices around the previous three year mean. Using the mean of the previous three years can be considered the price expectation Arkansas producers' will receive for their crops and pay for key productions inputs. Summary statistics of simulated Arkansas crop prices, fertilizer, diesel fuel, and glyphosate prices are presented in Table 2.

Yields. Summary statistics of simulated yields by tillage and crop rotation are presented in Table 3. Yields were detrended using linear regression and the residuals were used to simulate risk in yields around the mean. The mean crop yield used for the analysis was calculated from the 10 years of data. Wheat in some years had no yield due to planting failure. Those years are used in the MVE distribution and represent the risk producers may face under some rotations.

Continuous Rice (R), Rice-Soybean (RS), Rice-Corn (RC), Rice-Wheat (RW), and Rice-Wheat-Soybean-Wheat (RWSW) long term rotation studies managed under both NT and CT were conducted at the University of Arkansas Rice Research and Extension Center in Stuttgart, AR. The plot location was cut to a slope of 0.15% in February of 1999, and each plot measures

250-ft x 40-ft in a north-south direction. These plots were then divided in half ease-west with each side randomized as conventional or no-till treatments. Each tillage treatment was then split into two fertility treatments. During the study there has been no significant difference in yields by fertility treatment. For the purpose of this study the fertility treatment yield data were combined.

Plant residues were left on the no-till plots while conventional-till plots were burnt following harvest. Phosphorus and potassium fertilizers were applied prior to planting with both fertilizers incorporated with tillage in the conventional-till plots and left on the soil surface in the no-till plots. Herbicide use for weed control was generally the same from year to year between tillage and crop but all no-till plots with the exception of the rice/wheat plots had an early glyphosate application for weed control instead of tillage.

Risk Analysis. Simulated probability distributions of net returns for each tillage method and rotation are ranked according to risk attitudes using stochastic efficiency with respect to a function (SERF). The SERF method uses certainty equivalents (CE) for a specific range of risk aversion levels. A CE can be defined as the value of a certain payoff a decision maker would require for the chance of a higher payoff but an uncertain amount.

The SERF method compares each alternative investment, or in this case tillage and cropping system, simultaneously unlike stochastic dominance with respect to a function (Hardaker et al. 2004). The SERF method in Simetar uses a negative exponential utility function to estimate the CE values at each absolute risk aversion coefficient (ARAC). The ARAC formula proposed by Hardaker et al. (2004) is used to calculate a decision maker’s degree of risk aversion. As in Riberia et al. (2004) this analysis presents a range of ARACs to demonstrate the rankings for a range of decision makers. Additionally, the NT risk premiums are calculated for each rotation by subtracting the CT CE value from the NT CE value at the specific ARAC value. Given the CE values, risk premiums can be calculated across alternative cropping systems and between tillage practices.

Results

Net Returns. Summary statistics of simulated net returns by tillage and cropping system along with probabilities of negative net returns generated are presented in Table 4. Both the continuous R-NT and R-CT system has about a 43% chance of generating a negative return. The minimum, mean, and maximum returns per acre for R-NT are -$226, $62, and $661, respectively while R-CT results are -$220, $59, and $591, respectively. Mean net returns and variability are very similar by tillage for the continuous R cropping system. The RS-NT has about a 12% chance of obtaining negative net returns. The minimum, mean, and maximum per acre for RS-NT are -$104, $110, and $494, respectively. The RS-CT probability of generating negative net returns is 23% which is almost double that of NT. The minimum, mean, and maximum per acre for RS-CT are -$182, $83, and $452, respectively.

The RC-NT cropping system has about an 87% chance of generating negative net returns while the RC-NT has about an 80% chance. The RC-NT minimum, mean, and maximum per acre net returns are -$348, -$109, and $230, respectively. The RC-CT minimum, mean, and maximum per acre net returns are -$364, -$89, and $241, respectively. The RW-NT cropping system has about a 77% chance of generating negative net returns. The minimum, mean, and maximum per acre net returns are -$315, -$56, and $265, respectively. The RW-CT cropping system has an 83% chance of obtaining negative net returns while the minimum, mean, and maximum net returns per acre are -$295, -$70, and $223, respectively. The RWSW-NT cropping system has about a 73% chance of generating negative net returns while the RWSW-CT exhibits an 83% chance. The minimum, mean, and maximum net returns per acre for RWSW-NT are -$456, -$60, and $320, respectively. The RWSW-CT minimum, mean, and maximum net returns per acre are -$533, -$120, and $235, respectively.

Certainty Equivalents and Risk Premium to No-till. Certainty equivalents (CE) and NT risk premiums are presented by cropping system for a range of ARACs in Table 5 and are used to predict preferences of NT versus CT by cropping system in Figure 1. Certainty equivalents are equal to the mean (risk neutral) when the ARACs=0. Positive ARACs represent risk aversion, and risk aversion increases as ARACs become more positive. Alternatively, negative ARACs represent risk seeking behavior, and risk seeking behavior grows as ARACs become more negative. ARACs values from -0.15 to 0.15 are used to give a range of how the cropping systems and tillage practice would be ranked across risk aversion levels.

The CEs for the continuous R cropping system indicate that NT would be preferred by risk neutral and risk seeking producers. NT has a positive risk premium over CT of $3 to $70/acre as risk preference increases from risk neutral to risk seeking (ARACs = -0.15 to 0) but CT has a premium over NT of $6/acre as risk aversion increases meaning that risk averse producers would have to be paid $6/acre to adopt NT. The CEs for the RS cropping system indicate that NT would be preferred over CT across all risk attitudes. NT premiums over CT ranged from $27/acre (risk neutral) to $73/acre (highly risk adverse).

Producers in a RC cropping system would prefer CT if they are risk neutral or risk seeking. NT would be preferred as risk aversion increased. NT risk premiums over CT are $12/acre for risk adverse producers while CT has a premium over NT of $10/acre for risk seeking and $20/acre for risk neutral producers. The CEs for a RW cropping system are larger for NT if a producer is risk neutral or risk seeking. This is the exact opposite of the RC cropping system but the preferences are similar to the continuous R cropping system. NT risk premiums over CT are $15 to $41/acre for risk neutral and risk seeking, respectively. CT has a risk premium over NT of $17/acre as risk aversion increases. The CEs in the RWSW cropping system indicate that NT would be preferred over CT across all risk attitudes. NT premiums over CT ranged from $60/acre (risk neutral) to $93/acre (risk adverse).

The CEs for net returns are used in Figure 2 across ARACs to compare all five cropping systems for both NT and CT. Under NT, risk neutral producers would prefer the RS cropping system over the continuous R system, the second preferred, followed by RW, RWSW, and RC with risk premiums to RS over the other cropping systems per acre of $49, $166, $170, and $219, respectively. In order for a risk neutral no-till producer to switch from the RS cropping system, the premiums listed would have to be paid to the producer per acre to change to that specific cropping system. Risk-averse producers under NT would prefer RS over continuous R followed by RW, RC, and RWSW. The order of cropping systems slightly changed between risk neutral and risk adverse. Risk neutral no-till producers would prefer RWSW over RC but risk adverse producers would prefer RC over RWSW (Figure 2).

Under CT, risk neutral and risk adverse producers would prefer RS cropping system to continuous R, followed by RW, RC, and RWSW. Risk premiums to RS per acre over the other cropping systems for risk neutral conventional-till producers would be $24, $154, $172, and $203, respectively. Risk premiums to RS per acre over the other cropping systems for risk adverse conventional-till producers would be $37, $115, $181, and $350, respectively.

Summary and Conclusions

This analysis examined production costs, yields, profitability, and economic risk of NT on Arkansas Grand Prairie silt loam soils using simulation and SERF. Labor, fuel, and machinery costs were lower for NT than CT, but yields were usually lower on average in NT as compared to CT. Few Arkansas rice producers practice NT due to management issues and possibly little information about profitability and risk. The last objective of this study was to evaluate profitability and risk of rice based cropping systems. This was achieved by simulating crop and key input prices and yields. Net returns distributions were constructed for rice based cropping systems under CT and NT.

Net income results based on the mean by tillage, the system with highest return or least negative return, is continuous R-NT, RS-NT, RC-CT, RW-NT, and RWSW-NT. Risk premiums for risk neutral producers who prefer NT to CT ranged from -$20 to $60/acre while risk premiums for risk-averse producers ranged from -$17 to $77/acre. Negative values indicate that a producer with a defined risk preference would have to be paid to adopt NT over CT.

The results indicate that under NT and CT producers who are risk neutral and risk adverse would prefer the RS cropping systems over all other rotations followed by continuous R. The RS-NT has the highest mean and lowest probability of generating a negative income. This result explains why the majority of rice grown in Arkansas is rotated with soybeans and followed secondly by rice grown continuously. The RC-NT has the lowest mean and greatest chance of obtaining a negative income out of all the systems. The results also suggest that producers with a risk neutral preference would prefer NT over CT in four of the five cropping systems (R, RS, RW, RWSW) while a risk-averse producer would prefer NT over CT in three of the five cropping systems (RS, RC, RWSW).

Limitations and shortcomings of this study should be mentioned to provide full disclosure and assistance to interpreting the results. One limitation is that crops and rotations are constrained by the results in test plots and could be different for actual farming conditions. Another limitation is two fertility treatments were used in the test plots and combined for this study. The quantity of fertilizer used for each crop and within the specific rotation may not be economically optimal and therefore have an impact when comparing cropping systems. A third limitation is that simulated prices are constrained to their historical correlations which may change over time.

A shortcoming of this study is the focus solely on market returns. The study does not account for social benefits or incentives to adopt NT, i.e. carbon credits and federal conservation programs. Another shortcoming is the study focused on per acre returns and does not account for whole-farm activities. Using a mathematical programming model with simulated prices and yields could provide a detailed profit and risk analysis of crop rotations and tillage systems based upon specific resource availability.

References

Al-Kaisi, M.M. and X. Yin. 2004. Stepwise Time Response of Corn Yield and Economic Return to No-tillage. Soil and Tillage Research. 78:91-101.

Archer, D.W. and D.C. Reicosky. 2009. Economic Performance of Alternative Tillage Systems in the Northern Corn Belt. Agronomy Journal. 101:296-304.

Archer, D.W., A.D. Halvorson, and C.A. Reule. 2008. Economics of Irrigated Continuous Corn under Conventional-Till and No-Till in Northern Colorado. Agronomy Journal. 100:1166-1172.

Bierlen, R., and L.D. Parsch. 1996. Tenant Satisfaction with Land Leases. Review of Agricultural Economics. 18(2):505-513.

Burton, R.O., Jr., R.P. Smith, and A.J. Schlegel. 2009. Economics of Reduced-Till, No-Till, and Opportunity Cropping in Western Kansas. Journal of the ASFMRA. 72:164-176.

Epplin, F.M., T.F. Tice, A.E. Baquet, and S.J. Handke. 1982. Impacts of Reduced Tillage and Operating Inputs and Machinery Requirements. American Journal of Agricultural Economics. 64:1039-46.

Hardaker, J.B., J.W. Richardson, G. Lein, and K.D. Schumann. 2004. Stochastic Efficiency Analysis with Risk Aversion Bounds: A Simplified Approach. The Australian Journal of Agricultural and Resource Economics. 48(2):253-270.

Harper, T.W. 2006. Conservation-tillage effects on runoff water quality and soil physical properties in the Arkansas Delta. M.S. Thesis. University of Arkansas, Fayetteville, AR.

Krause, M.A. and J.R. Black. 1995. Optimal Adoption Strategies for No-Till Technology in Michigan. Review of Agricultural Economics. 17:299-310.

Nail, E.L., D.L. Young, and W.F. Schillinger. 2007. Diesel and glyphosate price changes benefit the economics of conservation-tillage versus traditional tillage. Soil and Tillage Research. 94:321-327.

Pearce, A.D., C.R. Dillon, T.C. Keisling, and C.E. Wilson. 1999. Economic and agronomic effects of four tillage practices on rice produced on saline soils. Journal of Production Agriculture. 12(2):305-312.

Peterson, D. 2005. U.S. tillage trends. Land and water, conserving natural resources in Illinois. Univ. of Illinois Extension. No. 6. Urbana, IL.

Rachman, A., S.H. Anderswon, C.J. Gantzer, and A.L. Thompson. 2003. Influence of long-term cropping systems on soil physical properties related to soil erodibility. Soil Sci. Soc. Am. J. 67:637-644.

Renwick' W.H., M.J. Vanni, Q. Zhang, and J. Patton. 2008. Water Quality Trends and Changing Agricultural Practices in a Midwest U.S. Watershed, 1994–2006. Journal of Environmental Quality. 37:1862-1874.

Riberia, L.A., F.M. Hons, and J.W. Richardson. 2004. An Economic Comparison between Conventional and No-Tillage Farming Systems in Burleson County, Texas. Agronomy Journal. 96:415-424.

Richardson, J.W, K.D. Schumann, and P.A. Feldman. 2008. SIMETAR: Simulation and Econometrics To Analyze Risk. Simetar, Inc. College Station, TX.

Richardson, J.W., S.L. Klose, and A.W. Gray. 2000. An Applied Procedure for Estimating and Simulating Multivariate Empirical (MVE) Probability Distributions in Farm-level Risk Assessment and Policy Analysis. Journal of Agricultural and Applied Economics. 32(2):299-315.

Smith, R.J., Jr., and A.M. Baltazar. 1992. Reduced and no-tillage systems for rice and soybeans. B.R. Wells Rice Research Studies. AAES Research Series 422:104-107.

Watkins, K.B., J.L. Hill, and M.M. Anders. 2008. An Economic Risk Analysis of No-Till Management and Rental Arrangements in Arkansas Rice Production. Journal of Soil and Water Conservation. 63(4):242-250.

Watkins, K.B., M.M. Anders, and T.E. Windham. 2004. An Economic Comparison of Alternative Rice Production Systems in Arkansas. Journal of Sustainable Agriculture. 24(4):57-78.

West, T.O. and W.M. Post. 2002. Soil Organic Carbon Sequestration Rates by Tillage and Crop Rotation: A Global Data Analysis. Soil Sci. Soc. Am. J. 66:1930–1946 (2002).

Williams, J.R., D.L. Pendell, R.V. Llewelyn, D.E. Peterson, and R.G. Nelson. 2009. Returns to Tillage Systems under Changing Input and Output Market Conditions. Journal of the ASFMRA. 72:78-93.

Wilson, C.W. and J.W. Branson. 2002. Trends in Arkansas Rice Production. B.R. Wells Rice Research Studies. AAES Research Series 504:15-20.

Wilson, C.E. and S.K. Runsick. 2008. Trends in Arkansas Rice Production. B.R. Wells Rice Research Studies. AAES Research Series 571:13-23.

USDA National Agricultural Statistical Service. 2008. Quick Stats U.S. and All States Data. Access at: www.nass.usda.gov

Table 1. Budgets for no-till (NT) and conventional-till (CT) by crop.

	Early Rice		Late Rice		Corn		Early Soybeans		Late Soybeans		Wheat	
	NT	CT	NT	CT	NT	CT	NT	CT	NT	CT	NT	CT
	-------------------------------$/acre-------------------------------											
Fertilizers	114	114	114	114	200	200	51	51	51	51	96	96
Fungicides	0	0	0	0	0	0	0	0	0	0	2	2
Herbicides	81	77	94	90	60	48	21	16	18	11	27	27
Insecticides	1	1	5	5	0	0	0	0	0	0	0	0
Irrigation Supplies	8	8	8	8	7	7	8	8	8	8	0	0
Crop Seed	59	59	22	22	72	72	43	43	43	43	18	18
Adjuvants	4	4	7	7	4	4	3	2	2	2	0	0
Custom Hire	42	42	46	46	46	40	24	16	22	17	30	30
Labor	13	18	13	18	6	11	6	12	6	12	4	9
Diesel Fuel	104	119	114	126	50	63	42	55	42	55	9	22
Repair/Maintenance	17	21	18	22	11	16	10	14	10	14	6	9
Interest	13	14	11	11	14	14	6	6	5	6	6	7
Direct Costs	456	476	453	471	469	474	216	224	209	218	198	220
Fixed Costs	74	92	74	92	50	71	52	71	52	71	22	41
Total Costs	530	569	528	563	519	545	268	294	261	288	220	261

Table 2. Summary statistics for simulated crop and key input prices.

	Unit	Mean	Standard Deviation	CV	Minimum	Maximum
Crop Prices[1]						
LG Rice	$/bu	6.09	1.41	23.22	4.39	9.84
Soybeans	$/bu	9.35	1.14	12.19	7.80	11.14
Corn	$/bu	3.79	0.44	11.54	2.87	4.37
Wheat	$/bu	4.97	0.56	11.22	4.24	6.21
Input Prices						
Potash	$/lb	0.38	0.32	83.4	0.17	1.30
Phosphate	$/lb	0.33	0.11	32.7	0.22	0.57
Urea	$/lb	0.25	0.04	15.5	0.19	0.33
Diesel	$/gal	2.59	0.61	23.5	1.61	3.74
Glyphosate	$/pt	4.69	0.61	13.0	3.64	5.83

[1] Crop prices are Arkansas simulated prices.

Table 3. Summary statistics for simulated yields by cropping system and tillage practice.

Cropping System	Crop	Tillage	Mean	Standard Deviation	CV	Minimum	Maximum
			-----------------------bu/acre-----------------------				
Rice							
	Rice	NT	151	15	10	130	182
	Rice	CT	160	11	7	146	182
Rice-Soybean							
	Rice	NT	179	13	7	165	209
	Rice	CT	183	13	7	162	198
	Soybean	NT	50	8	16	38	64
	Soybean	CT	49	14	29	17	72
Rice-Corn							
	Rice	NT	175	11	7	157	201
	Rice	CT	182	14	8	159	208
	Corn	NT	81	29	35	38	135
	Corn	CT	111	30	27	77	187
Rice-Wheat							
	Rice	NT	111	32	29	64	164
	Rice	CT	124	24	19	72	158
	Wheat	NT	22	23	102	0	64
	Wheat	CT	32	26	81	0	64
Rice-Wheat-Soybean-Wheat	Rice	NT	125	30	24	68	175
	Rice	CT	122	29	24	47	154
	Wheat[1]	NT	25	21	84	0	55
	Wheat[1]	CT	32	26	80	0	63
	Soybean	NT	37	13	35	15	56
	Soybean	CT	32	13	40	8	52
	Wheat[2]	NT	34	28	83	0	67
	Wheat[2]	CT	37	30	81	0	68

[1] Wheat planted after rice in the rotation.

[2] Wheat planted after soybeans in the rotation.

Table 4. Summary statistics of simulated net returns by cropping system and tillage practice.

Rotation	Tillage	Prob. of negative returns	Mean	Standard Deviation	CV	Minimum	Maximum
			----------------------------	----------------------------	$/acre	----------------------------	----------------------------
Rice	NT	0.43	62	158	256	-226	661
	CT	0.43	59	151	255	-220	591
Rice-Soybean	NT	0.12	110	104	94	-104	494
	CT	0.23	83	111	133	-182	452
Rice-Corn	NT	0.87	-109	97	-89	-348	230
	CT	0.80	-89	104	-117	-364	241
Rice-Wheat	NT	0.77	-56	91	-164	-315	265
	CT	0.83	-70	82	-116	-295	223
Rice-Wheat-	NT	0.73	-60	125	-209	-456	320
Soybean-Wheat	CT	0.83	-120	128	-106	-533	235

Table 5. Cropping systems and tillage certainty equivalents and no-till risk premium by various absolute risk aversion coefficients.

		Absolute risk aversion coefficients				
Rotation	Tillage	-0.15	-0.075	0	0.075	0.15
		Certainty equivalents ($/acre)				
Rice	NT	619	580	62	-145	-185
	CT	550	511	59	-139	-178
Rice-Soybean	NT	453	412	110	-42	-69
	CT	411	371	83	-106	-142
Rice-Corn	NT	190	153	-109	-279	-312
	CT	200	162	-89	-285	-323
Rice-Wheat	NT	223	184	-56	-234	-274
	CT	182	144	-70	-224	-257
Rice-Wheat-Soybean-Wheat	NT	282	249	-60	-374	-415
	CT	194	157	-120	-454	-492
		No-till risk premiums ($/acre)				
Rice		70	69	3	-6	-6
Rice-Soybean		42	41	27	65	73
Rice-Corn		-10	-9	-20	6	12
Rice-Wheat		41	40	15	-10	-17
Rice-Wheat-Soybean-Wheat		88	93	60	80	77

Note: Positive risk premium is benefit to NT while negative value is benefit to CT.

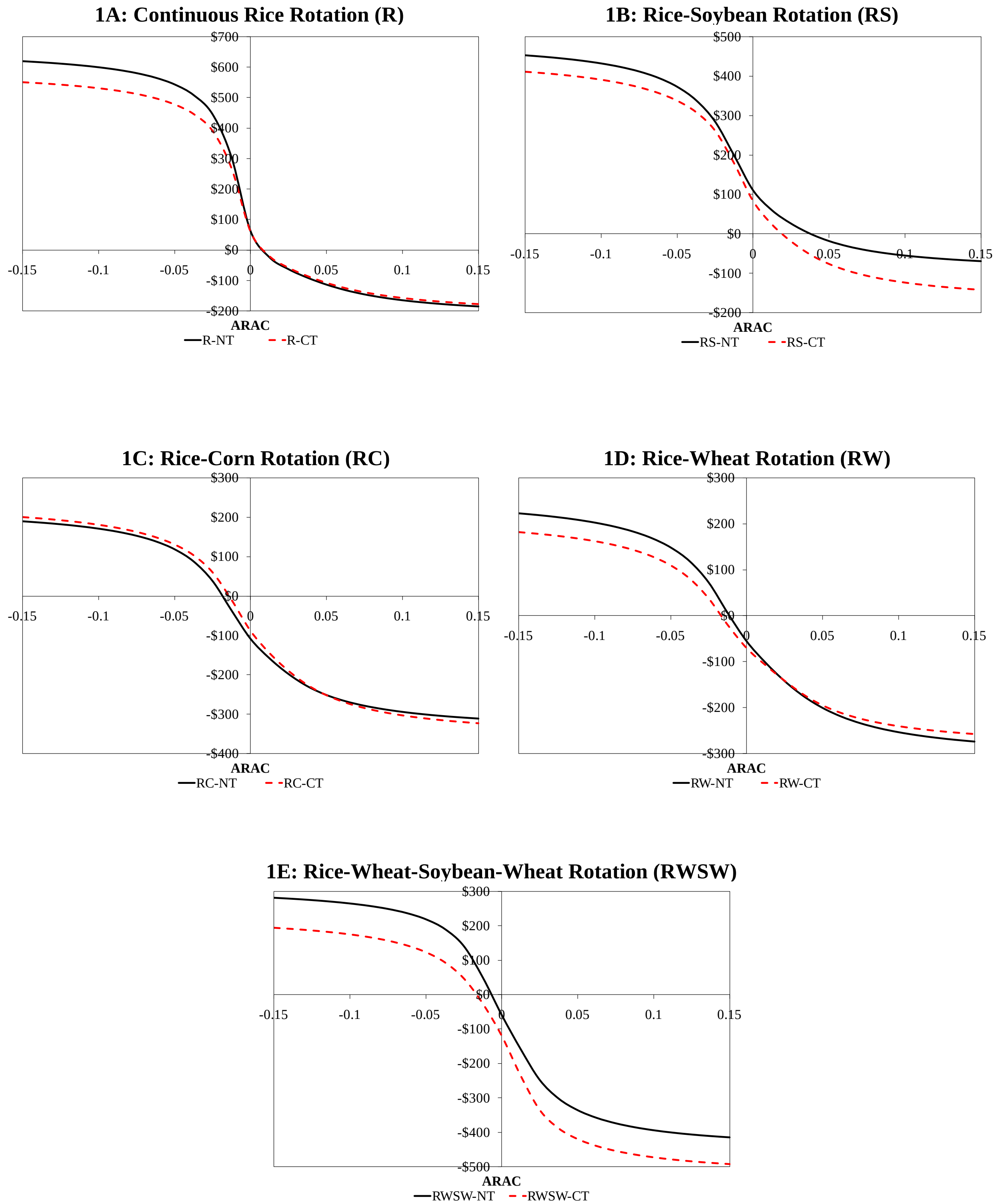
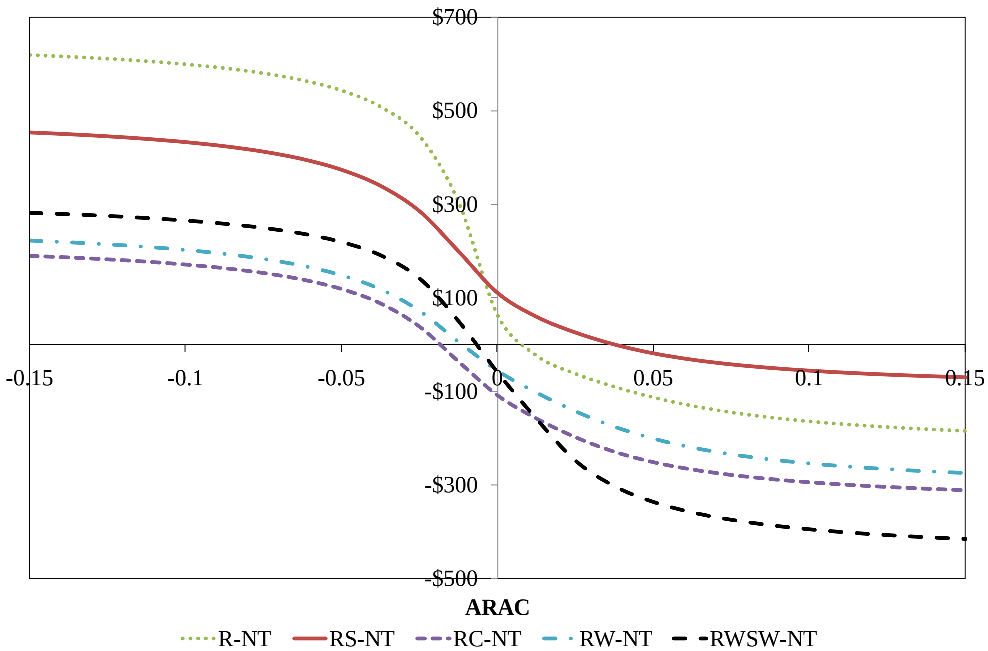


Figure 1. Certainty equivalents for net returns of no-till (NT) and conventional-till (CT) cropping systems on the Arkansas Grand Prairie.

2A: No-tillage systems



2B: Conventional-tillage systems

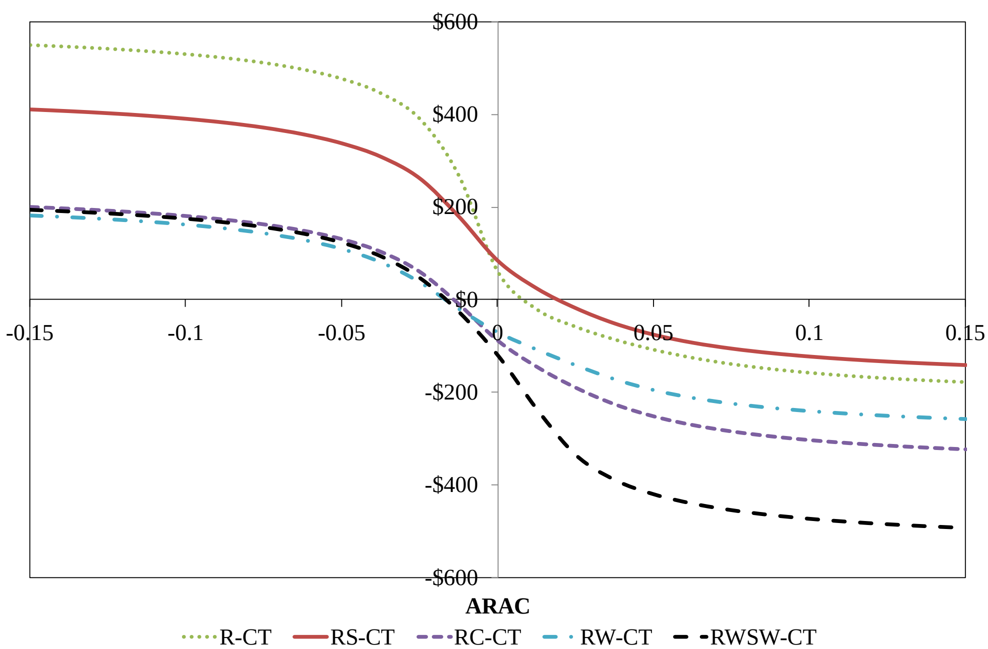


Figure 2. Certainty equivalents for net returns of no-till (NT) and conventional-till (CT) systems for five rotations on the Arkansas Grand Prairie. R, continuous rice; RS, rice-soybean; RC, rice-corn; RW, rice-wheat; RWSW, rice-wheat-soybean-wheat.