An Economic Risk Analysis of No-till Management for the Rice-Soybean Rotation System Used in Arkansas

T. Hristovska, K.B. Watkins, and M.M. Anders

ABSTRACT

Arkansas is the top domestic rice producer, representing nearly half of total U.S. rice production. Sediment is one of the major pollutants in rice-producing areas of Arkansas. In order to mitigate this problem, no-tillage (NT) management is often recommended. No-tillage is not well understood by farmers who believe that NT is less profitable due to lower yields offsetting cost savings. This study evaluates the profitability and variability of NT in the typical rice-soybean rotation used in Arkansas rice production. Crop yields, prices, and prices for key production inputs (fuel and fertilizer) are simulated for the rotation, and net return distributions for rice, soybean, and the two-year rotation are evaluated for NT and conventional till. The results indicate that no-till soybeans contribute greatly to the overall profitability of the NT rotation.

INTRODUCTION

Arkansas is the leading rice-producing state in the United States, accounting for over 45% of total U.S. rice production in 2009 (USDA, ERS, 2011). Historically, rice has been of great importance for the Arkansas economy. Rice is Arkansas’ highest valued crop, accounting for 37% of crop production value for the state in 2010 (USDA, NASS, 2011). Approximately 1.78 million acres of rice were harvested in 2010 in Arkansas, yielding approximately 6,480 lb and producing about 115.67 million cwt of rice. Arkansas’s 2010 rice production was valued at approximately $1.3 billion (USDA, NASS, 2011).

Rice is typically rotated with soybeans in Arkansas. Although rice is a more profitable crop than soybean, the latter crop is generally rotated with rice as a means
of controlling red rice, a close weed relative to rice. A two-year rice-soybean rotation is
typical for most rice acreage in Arkansas. In 2009, the rice-soybean rotation accounted
for almost 68% of Arkansas rice acreage (Wilson et al., 2009). However, some acres
may be continuous rice or rotated with other crops such as corn, sorghum, cotton, and
wheat (Wilson et al., 2009).

Nearly all rice is produced in the eastern part of Arkansas along the Mississippi
Delta region. Agriculture, geography, and climate have major impacts to surface water
quality in eastern Arkansas. According to Kleiss et al. (2000), eastern Arkansas soils
are predominantly composed of dense alluvial clay sub-soils that limit water infiltra-
tion. Surface soils contain silt and clay particles that are moved by heavy rainfall from
tilled fields, and these soils also contain little organic matter (Huitink et al., 1998).
Sediment is the primary pollutant identified for most eastern Arkansas waterways, and
conservation practices like no-tillage (NT) are commonly recommended as remedial
mechanisms (Huitink et al. 1998). While conventional-till (CT) is cultivation intensive,
NT provides maximum erosion control, conserves soil moisture, improves soil organic
matter, and has lower fuel and labor input costs (USDA NRCS, 2006).

Conventional rice production in Arkansas involves intensive cultivation. Fields
are “cut-to-grade” every few years, disked annually in either late fall or early spring,
and “floated” (land planed) annually in early spring to ensure smooth water movement
across the field. In 2009, conventional till (spring tillage and floating) accounted for
52.5% of all planted rice acres in Arkansas, while stale seedbed (fall tillage followed
by burn-down herbicides prior to planting in the spring) accounted for over 35.3% of
planted rice acres. True NT management (rice planted directly into the previous crop
residue without tillage at any time) accounted for 12.2% of planted Arkansas rice acres
in 2009 (Wilson et al., 2009).

The profitability of NT rice has been investigated using enterprise budget analysis
(Hignight et al., 2009), whole-farm analysis (Watkins et al., 2006), and risk analysis
from the perspectives of both the landlord and the tenant in typical Arkansas tenure
arrangements (Watkins et al., 2008). Hignight et al. (2009) evaluated the economic
contributions of both rice and soybean to the rotation under NT management but did
not conduct a risk analysis. The two other studies looked solely at returns to the rice-
soybean rotation under NT management and did not evaluate the economic contributions
made by either rice or soybean to the rotation. The Watkins et al. (2008) study also
considered only price and yield risk and did not evaluate systematic production cost
risk associated with high and volatile fuel and fertilizer prices. Rice in particular is a
high-cost crop relative to other field crops due to its large fuel, fertilizer, and irrigation
expenses (Childs and Livezey, 2006).

The objective of this study is to evaluate the profitability of NT relative to CT
management for the typical rice-soybean production system used in Arkansas rice
production. Crop yields, crop prices, and prices for key production inputs (diesel and
fertilizer) are simulated and net return distributions for rice, soybean, and the two-year
rotation are evaluated separately for both NT and CT management.
PROCEDURES

Crop yields, crop prices, and prices for fuel and fertilizer were simulated using the Excel Add-In, SIMETAR (Richardson et al., 2008). Multivariate empirical distributions (MVEs) were used to simulate 500 iterations of yields and prices. A MVE distribution simulates random values from a frequency distribution made up of actual historical data and has been shown to appropriately correlate random variables based on their historical correlation (Richardson et al., 2000). Parameters for the MVE include the means, deviations from the mean or trend expressed as a fraction of each variable, and the correlation among variables. The MVE distribution is used in instances where data observations are too few to estimate parameters for another distribution (Pendell et al., 2006).

Rice and soybean yield distributions under CT and NT were simulated using 11 years of historical yield data from a long term rice-based cropping systems study at Stuttgart, Ark., for the period 2000 to 2010 (Anders and Hignight, 2010). The historical crop yields represent yields obtained in a two-year rice-soybean rotation. Deviations from 11-year means were used to estimate the parameters for the MVE yield distributions, and mean yields over the 11-year period were used as expected yields for the MVE yield distributions. Summary statistics for the simulated yields are presented in Table 1. Rice yields for NT are lower by approximately 100bu/acre than CT rice yields. Soybean yields for NT on the other hand are higher for about 1bu/acre for NT than CT soybean. Anders and Hignight (2010) also found that, over time, NT rice yields declined compared to CT, while NT soybean yields steadily increased compared to CT.

Multivariate empirical distributions were used to simulate crop prices (rice, soybean) and prices for key production inputs (diesel, urea, phosphate, and potash). All price simulations were based on historical prices obtained from the USDA, National Agricultural Statistics Service (2002, 2006, 2009, 2010 a,b) for the 2000 to 2010 period, adjusted to 2010 dollars using the Producer Price Index. Deviations from the means and their associated correlations were used to simulate the MVE price distributions for each price series, but mean prices for the period 2005 to 2010 were used rather than 11-yr means to represent expected prices for the MVE price distributions. Prices for the latter five years of the 11-yr period better represent current farmer price expectations. The MVE approach has been shown to reproduce the historical correlation matrix and maintain the historical coefficient of variation from the original historical data series even when using means different from the historical mean (Ribera et al., 2004). Summary statistics for simulated prices are presented in Table 1.

Direct and fixed expenses for the analysis were based on cost data used in the 2010 Arkansas Rice Research Verification Program (Runsick et al., 2010) and input data for rice and soybeans grown in a two-year rotation obtained from the long term rice cropping systems study at Stuttgart, Ark. Direct expenses included expenses associated with fertilizer, pesticides, seed, operator labor, machinery and irrigation fuel, machinery and irrigation repairs and maintenance, and interest on operating capital. Fixed expenses included machinery and irrigation depreciation and interest. Average budgeted expenses are presented by crop enterprise and tillage method on a per hectare basis in Table 2.
No-till is less labor and machinery intensive, therefore it is a fuel saving practice, but it requires more herbicide and custom chemical/fertilizer applications. Average direct expenses for NT rotation were found to be $396.02/acre, while CT rotation average direct expenses were $403.15/acre. The NT fixed expenses were also found to be lower on average than CT rotation fixed expenses ($65.58/acre for NT; $78.55/acre for CT). Consequently, total expenses for NT rotation were lower on average than those for CT rotation ($461.59/acre for NT; $481.70/acre for CT).

Using the above data, net returns per acre for the rice-soybean rotation were estimated based on the 500 simulated iterations using the following formula:

\[ NR_j = 0.5 \sum_{i=1}^{2} \left( \left( Y_{ij} \times P_{ij} \right) - SVC_{ij} - SHC_{ij} - NSVC_i - F_i \right) \]

where \( i = 1 \) to 2 crops (rice, soybean); \( j = 1 \) to 500 simulated iterations; \( NR_j \) is the total net revenue per hectare of the rice-soybean rotation for iteration \( j \); \( Y_{ij} \) is the stochastic yield per hectare of crop \( i \) and iteration \( j \); \( P_{ij} \) is the stochastic price per kilogram for crop \( i \) and iteration \( j \); \( SVC_{ij} \) is the total stochastic variable cost of fuel and fertilizer per hectare of crop \( i \) and iteration \( j \); \( SHC_{ij} \) is the total stochastic harvest cost per hectare of drying, check off and hauling for crop \( i \) and iteration \( j \); \( NSVC_i \) is the total non-stochastic variable cost per hectare for crop \( i \); and \( F_i \) is the fixed cost per hectare for crop \( i \). Equation 1 is multiplied by 0.5 to reflect a rotation of 50% rice and 50% soybeans.

**RESULTS AND DISCUSSION**

**Net Returns to Rice, Soybean, and the Rotation**

Summary statistics of simulated net returns to rice, soybean, and the two-year rotation are presented by tillage method in Table 3. Average returns to rice in the two-year rotation are slightly larger for CT than for NT, but the relative variability of returns to rice under the two tillage methods as measured by the coefficient of variation is equal (CV = 70 for both CT rice and NT rice net returns). Average returns to soybean are lower than average returns to rice regardless of the tillage method used, implying rice is the more profitable crop in the two-year rotation. However, the soybean average returns are larger under NT than under CT management, and the relative variability of soybean returns is smaller for NT than for CT (CV = 73 for NT soybean; CV = 101 for CT soybean). Average returns for the two-year rotation are also slightly larger and less variable under NT management than under CT management. These results are due primarily to the soybean portion of the rotation, which is both more profitable and less risky under NT management. In all three instances (rice, soybeans, and the rotation), the minimum and maximum returns are larger for NT than for CT. These results imply NT performs better than CT in both “poor” crop years (higher minimum returns) and “good” crop years (higher maximum returns) for both rotation crops and the rotation itself.

Besides being more profitable, no-till can reduce sediment run-off and contribute to improved water and soil conservation. Lower fuel emissions are also one of the many
no-till benefits that result from lowered machine fuel usage. No-till management may also contribute to carbon sequestration in rice production. This study evaluates profitability only and does not seek to quantify environmental benefits of no-till management. Given the great interest in soil and water conservation practices, future studies should be conducted to measure such benefits.

SIGNIFICANCE OF FINDINGS

This study evaluates the profitability and risk efficiency of NT for the typical rice-soybean rotation used in Arkansas based on data from a continuous 10-yr study. Net return distributions for rice, soybean, and the two-year rotation are evaluated separately for both NT and CT management. The results support previous findings that NT management is indeed more profitable on average but more importantly this study evaluates and highlights the case of rice-soybean rotation that is most commonly used in Arkansas. These results indicate that NT soybeans contribute greatly to the overall profitability of the rice-soybean rotation.

ACKNOWLEDGMENTS

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LITERATURE CITED


Richardson, J.W., K.D. Schumann, and P.A. Feldman. 2008. SIMETAR, Simulation & Econometrics to Analyze Risk. College Station: Agricultural and Food Policy Center, Department of Agricultural Economics, Texas A&M University, 2008.


Table 1. Summary statistics of simulated yields and prices.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>CV</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT rice yield (bu/acre)</td>
<td>184.07</td>
<td>12.49</td>
<td>6.78</td>
<td>159.84</td>
<td>199.25</td>
</tr>
<tr>
<td>NT rice yield (bu/acre)</td>
<td>177.21</td>
<td>13.45</td>
<td>7.59</td>
<td>161.75</td>
<td>209.25</td>
</tr>
<tr>
<td>CT soybean yield (bu/acre)</td>
<td>47.02</td>
<td>14.52</td>
<td>30.89</td>
<td>16.68</td>
<td>65.88</td>
</tr>
<tr>
<td>NT soybean yield (bu/acre)</td>
<td>48.06</td>
<td>11.48</td>
<td>23.89</td>
<td>31.25</td>
<td>68.31</td>
</tr>
<tr>
<td>Rice price ($/bu)</td>
<td>5.45</td>
<td>1.56</td>
<td>28.55</td>
<td>2.92</td>
<td>7.88</td>
</tr>
<tr>
<td>Soybean price ($/bu)</td>
<td>9.09</td>
<td>1.68</td>
<td>18.51</td>
<td>6.54</td>
<td>11.85</td>
</tr>
<tr>
<td>Diesel price ($/gal)</td>
<td>2.47</td>
<td>0.78</td>
<td>31.47</td>
<td>1.54</td>
<td>4.28</td>
</tr>
<tr>
<td>Urea ($/lb)</td>
<td>0.22</td>
<td>0.04</td>
<td>19.91</td>
<td>0.14</td>
<td>0.29</td>
</tr>
<tr>
<td>Phosphate ($/lb)</td>
<td>0.24</td>
<td>0.09</td>
<td>38.74</td>
<td>0.17</td>
<td>0.52</td>
</tr>
<tr>
<td>Potash ($/lb)</td>
<td>0.23</td>
<td>0.13</td>
<td>53.91</td>
<td>0.14</td>
<td>0.59</td>
</tr>
</tbody>
</table>

a CT = conventional till; NT = no-till.
b Summary statistics calculated from 500 simulated iterations.
c SD = Standard deviation.
d Coefficient of variation (CV) is a unitless measure of relative risk and is equal to 100 multiplied by the quotient of the standard deviation divided by the mean.
Table 2. Average direct and fixed expenses for a rice-soybean rotation by crop, rotation, and tillage, 2010 dollars.

<table>
<thead>
<tr>
<th>Expense item</th>
<th>Rice</th>
<th>Soybean</th>
<th>Rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CT</td>
<td>NT</td>
<td>CT</td>
</tr>
<tr>
<td>Seed</td>
<td>69.48</td>
<td>69.48</td>
<td>58.80</td>
</tr>
<tr>
<td>Fertilizers&lt;sup&gt;b&lt;/sup&gt;</td>
<td>113.48</td>
<td>113.48</td>
<td>60.93</td>
</tr>
<tr>
<td>Agrotain</td>
<td>8.15</td>
<td>8.15</td>
<td>0.00</td>
</tr>
<tr>
<td>Herbicide</td>
<td>64.04</td>
<td>70.68</td>
<td>8.72</td>
</tr>
<tr>
<td>Insecticide</td>
<td>0.54</td>
<td>0.54</td>
<td>0.00</td>
</tr>
<tr>
<td>Custom chemical application</td>
<td>38.00</td>
<td>38.00</td>
<td>17.25</td>
</tr>
<tr>
<td>Irrigation supplies</td>
<td>7.45</td>
<td>7.45</td>
<td>1.95</td>
</tr>
<tr>
<td>Survey levees</td>
<td>5.50</td>
<td>5.50</td>
<td>0.00</td>
</tr>
<tr>
<td>Labor</td>
<td>10.78</td>
<td>8.67</td>
<td>7.80</td>
</tr>
<tr>
<td>Diesel fuel&lt;sup&gt;b&lt;/sup&gt;</td>
<td>110.70</td>
<td>95.98</td>
<td>50.57</td>
</tr>
<tr>
<td>Repairs &amp; maintenance</td>
<td>21.71</td>
<td>20.36</td>
<td>11.89</td>
</tr>
<tr>
<td>Post-harvest expenses&lt;sup&gt;b&lt;/sup&gt;</td>
<td>107.41</td>
<td>103.41</td>
<td>11.76</td>
</tr>
<tr>
<td>Interest on operating capital</td>
<td>13.01</td>
<td>12.65</td>
<td>6.39</td>
</tr>
<tr>
<td>Total direct expenses</td>
<td>570.25</td>
<td>554.35</td>
<td>236.05</td>
</tr>
<tr>
<td>Fixed expenses</td>
<td>102.30</td>
<td>87.42</td>
<td>54.79</td>
</tr>
<tr>
<td>Total expenses</td>
<td>672.56</td>
<td>641.77</td>
<td>290.84</td>
</tr>
</tbody>
</table>

<sup>a</sup> CT = conventional till; NT = no-till.
<sup>b</sup> Expense item is stochastic (average calculated from 500 simulated iterations).

Table 3. Summary statistics of net returns for a rice-soybean rotation by tillage, crop, and rotation.

<table>
<thead>
<tr>
<th>Variable&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Mean&lt;sup&gt;b&lt;/sup&gt;</th>
<th>SD&lt;sup&gt;c&lt;/sup&gt;</th>
<th>CV&lt;sup&gt;d&lt;/sup&gt;</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>($/acre)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CT Rice</td>
<td>331.00</td>
<td>232.23</td>
<td>70.16</td>
<td>-109.37</td>
<td>772.22</td>
</tr>
<tr>
<td>NT Rice</td>
<td>324.49</td>
<td>226.75</td>
<td>69.88</td>
<td>-84.31</td>
<td>831.04</td>
</tr>
<tr>
<td>CT Soybean</td>
<td>136.60</td>
<td>138.27</td>
<td>101.23</td>
<td>-207.35</td>
<td>392.41</td>
</tr>
<tr>
<td>NT Soybean</td>
<td>155.85</td>
<td>114.10</td>
<td>73.21</td>
<td>-33.98</td>
<td>421.73</td>
</tr>
<tr>
<td>CT Rotation</td>
<td>233.80</td>
<td>163.46</td>
<td>69.91</td>
<td>-121.57</td>
<td>582.32</td>
</tr>
<tr>
<td>NT Rotation</td>
<td>240.17</td>
<td>155.76</td>
<td>64.85</td>
<td>-58.76</td>
<td>621.82</td>
</tr>
</tbody>
</table>

<sup>a</sup> CT = conventional till; NT = no-till.
<sup>b</sup> Summary statistics calculated from 500 simulated iterations.
<sup>c</sup> SD = Standard deviation.
<sup>d</sup> Coefficient of variation (CV) is a unitless measure of relative risk and is equal to 100 multiplied by the quotient of the standard deviation divided by the mean.