Applied Risk Analytics

Comparing Conventional and Strip-till Tillage Systems

Brothers Ken and Rich Riff* own and operate a row crop operation situated in Big Horn County, Wyoming. Currently the Riffs are considering converting the tillage portion in their operation from conventional tillage (using a disk harrow and moldboard plow) to a strip-till system (a more minimum-tillage approach). The Riffs like the idea of reducing the number of tillage passes, especially with high fuel costs, as well as the conservation benefits such as reducing erosion and crop water needs. They would like to examine the per acre costs of switching to a strip-till system, as well as look at the potential long-term benefits and costs associated with making a change. For purposes of our analysis, we will examine how this system would work for only one crop: corn.

Tillage Systems Overview

Currently the Riffs prepare a seedbed for corn the same way they have for many years, Table 1. They first run a stalk chopper over the field to size the previous year's crop residue to a manageable size. They then use a disk harrow twice to further break down and incorporate the residue. This is followed by a moldboard plow to further bury residue and create a seedbed. The field is finished with a roller harrow. Corn is then ready to be planted.

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The main advantages of this conventional tillage approach are that equipment is common and readily available, it often makes for clean seedbeds to start with, and requires fewer chemical inputs, especially important in organic farming systems. The disadvantages lie in the number of passes required, resulting in high fuel and input consumption, and the potential for erosion and reduction of soil organic matter. Soil moisture or lack of it becomes a problem, especially in drought years, the more a field is tilled.

The minimum tillage system the Riffs are considering switching to is often referred to as a strip-till system. The basic concept is to leave as much of the soil profile intact as possible, while tilling just a narrow strip (6-8 inches) that

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Table 1. Conventional Tillage System Overview.

Field Operations	Features
Chop Stalks Disk Harrow Disk Harrow Moldboard plow Roller Harrow Leveler/land plane	**Pros:** Breaks down residue Clean, level seedbed Common equipment **Cons:** High fuel and input consumption High erosion potential Reduces soil moisture, organic matter

Table 2. Strip-Till System Overview.

Field Operations	Features
Chop Stalks Strip-Till Plant Spray Weeds	**Pros:** Eliminates tillage passes Lowers erosion potential Place fertilizer on same pass Saves soil moisture **Cons:** Expensive equipment May require change in technology

the crop will be planted into. Many strip-till machines allow for applying fertilizer, further eliminating passes later in the season. The system the Riffs are looking at would include a stalk-chopping pass, followed by the strip-till pass, a herbicide application to kill weeds, and then plant corn, Table 2.

There are several advantages to the strip-till system, including fewer field operations that results in fewer inputs used, crop nutrients/fertilizers are placed at the desired level and eliminate at least some future applications, soil moisture losses are minimized, erosion potential is reduced, and soil structure and organic matter is maintained at a higher level. The potential downsides of this system can be the price of the equipment and, often, the need to upgrade to a tractor guidance system. This is due to the narrow rows that must be precisely and repeatedly accessed, for example planting down the same rows previously tilled.

Machine Risk Calculator Tool

The Riff Brothers need to compare the operating costs of the two tillage systems. The Machine Risk Calculator (MRC) was developed to calculate overall machinery costs, including: expected life values, repairs and depreciation, housing, insurance, taxes. Users can estimate expenses for powered equipment, three different implements, vehicles, powered irrigation equipment, non-powered irrigation equipment, and actual field operation costs using the tool. The resulting tables and graphs are based on the user data entered and provide estimates of the annual costs and average operating costs for each machine. Included in the tool are tables showing ranges of reported custom rates and information for selected activities in Wyoming.

The Riffs enter their machine data into the MRC tool. This will provide a cost per acre and cost per hour comparison for the two systems. To get started, the Riffs plan to use the same 200 horsepower tractor for both the conventional and strip-till operations. It is a used machine, with a $100,000 value and the associated repair and cost factors (found in the MRC tool appendix). They assume a 9 percent opportunity cost, covering both interest and inflation, and a rate for taxes housing and insurance of 2 percent.

Table 3. MRC Output for Disk Harrow Field Operation.

ESTIMATED FIELD OPERATION COSTS PER ACRE COVERED

	DEPR	OPP COST	THI	REPAIRS	FUEL & OIL	TOTAL COST
WHEEL TRACTOR - 200 PTO HP CAB, AIR, STR, PWRSFT	$0.35	$0.37	$0.08	$0.33	$3.24	$4.37
DISK HARROW FOLDING, 25 FT WIDTH	$0.87	$1.08	$0.24	$0.60	N/A	$2.79
	-	-	-	-	-	-
	-	-	-	-	-	-
Total Machine Cost PER ACRE:	$1.21	$1.45	$0.32	$0.93	$3.24	$7.16
Operating Inputs:						-
Operator Labor:						$1.72
Return to Management:						$1.72
Total Field Operation Cost PER ACRE						$10.59

The Riff's plow, disk harrow and roller harrow are also used, worth approximately $30,000 each. They use the associated repair and cost factors each machine found in the tool appendix. The MRC generates a results page showing the cost per acre and cost per hour, based on field speed and assumed hours of annual use, Table 3. After running the tool for each field operation, due to the difference in implement widths and speeds, we have a cost per acre for each summarized in Table 4. The total cost per acre for the conventional tillage system currently used by the Riffs is estimated at $85.86.

Next the Riffs will need to estimate the cost of using a strip-till machine with the same tractor. The brothers will stay with their current eight-row planter with 30-inch spacing and have located a slightly used strip-till machine for $50,000. Because there is no category for strip-till machines in the MRC tool, they use the cost and repair factors for a sub-soiler, which is a somewhat similar machine. The eight-row machine is 20-feet wide, and can be pulled 4 mph while applying fertilizer. The field efficiency remains the same as for the conventional tillage tools.

Results generated by the MRC tool provide an estimated cost per acre of $24.71, Table 5. This compares to an average rate of $24.72/acre for custom strip-till rates reported in Nebraska. At roughly 29 percent of the cost per acre of conventional tillage, the switch to strip-till seems like an easy choice so far. However, there is more to the decision that the Riffs must consider, especially the long term costs on a present value basis.

Multi-temporal Risk Analyzer Tool

A standard partial budget can be a useful approach when evaluating a change in management such as the Riff's are considering. However, a simple partial budget does not take into account the long-term effects of the proposed change. The Multi-Temporal Risk Analyzer (MTRA) is designed to provide users a long-term view of the uncertainty associated with the potential change being evaluated.

Table 4. Conventional Tillage Costs/Acre Summary.

Field Operation	$/Acre	$/Hour
Disk harrow	$10.59	154.09
Disk harrow	$10.59	154.09
Moldboard plow	$49.08	160.62
Roller harrow	$15.60	151.23
Total	**$85.86**	**$620.03**

Table 5. MRC Output for Strip-till Field Operation.

ESTIMATED FIELD OPERATION COSTS PER ACRE COVERED

	DEPR	OPP COST	THI	REPAIRS	FUEL & OIL	TOTAL COST
WHEEL TRACTOR - 200 PTO HP CAB, AIR, STR, PWRSFT	$0.65	$0.69	$0.15	$0.62	$6.08	$8.20
STRIP-TILL MACHINE 8 ROWS, 3	$2.71	$3.36	$0.75	$3.25	N/A	$10.07
	-	-	-	-	-	-
	-	-	-	-	-	-
Total Machine Cost PER ACRE:	$3.36	$4.05	$0.90	$3.87	$6.08	$18.27
Operating Inputs:						-
Operator Labor:						$3.22
Return to Management:						$3.22
Total Field Operation Cost PER ACRE						$24.71

The tool allows users to enter the expected benefits (increased returns and decreased costs) and expected costs (decreased returns and increased costs) over time. In this way, the user can adequately reflect the long-term expectations for the budgeted changes. In addition, MTRA allows the user to incorporate estimates of risk around any one of these potential benefits or costs by entering estimates for the maximum, minimum, and most likely values for each item. Using a range of potential values can help account for the inherent uncertainty in the process.

Another unique feature of the tool is the ability to include an item (check/un-check) each year as appropriate over the twenty year period of analysis. MTRA is capable of generating several different graphical outputs over an extended horizon, allowing the user to analyze various scenarios, as well as evaluate the effects of the interest rate (time value of money) via the cash and present value analysis tables.

MTRA Input

MTRA input is set up as a typical partial budget with four categories: added returns, reduced costs, added costs, and reduced returns. The Riffs plan to use the machinery on 400 acres of corn each year. After making sure the machine will meet their needs, they plan to sell the plow and the roller harrow, conservatively hoping to receive $40,000 or $100 per acre. They enter this value as an added return, with a maximum of $150, assuming the machines sell at a good price and a minimum of $80 per acre, to reflect a lower sales value, Table 6. They select only Year 2 for this value, by checking the appropriate box for the added return. Under reduced costs the Riffs enter the tillage costs of $86/acre that would no longer performed. For the low they enter $60 and a high of $100. In addition, they select all 20 years as the duration. Under added costs they enter the estimated cost of the strip-till operations as of $25 per acre, with a low of $20 and a high of $40; they also select all 20 years for the duration.

In addition, a machine payment must also be accounted for as an added cost within the first five years. The Riffs can finance the $50,000 purchase over five years at 7.5 percent resulting in a payment of $12,358. This divided by 400 acres would result in a cost of $31 per acre. There would be no reduced returns in this situation. Finally, the Riffs enter 9 percent for the interest rate or opportunity cost at the top of the input screen.

MTRA Results

Clicking RUN on the input page generates a set of results under the output tab. Results for a single simulation run are shown on both a cash and net present value basis. A key feature of the MTRA tool is that it can generate probability analysis accounting for the variability outlined for each entry in the partial budget on the input screen. The tool provides results based on a thousand random draws of the potential outcomes on a Cash and Net Present Value (NPV) basis. The most likely outcome, one

Table 6. MTRA Example Strip-Till System Costs and Returns.

Proposed Change:	Interest Rate:	9.00%		~ Check the boxes below for year(s) affected by the proposed changes ~																			
Riff Brothers Switch to Strip-Till System	*Most Likely* VALUE	*Expected* Low/High Value		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Added Returns																							
Tillage Equipment sale	$ 100	$ 80 Low	All	☐	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		$ 150 High	None																				
Reduced Costs																							
Conventional Tillage Costs	$ 86	$ 60 Low	All	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
		$ 100 High	None																				
Fertilizer application cost	$ 10	$ 7 Low	All	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
		$ 15 High	None																				
Added Costs																							
Strip-Till Operations	$ 25	$ 20 Low	All	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
		$ 40 High	None																				
Strip-Till Machine Payment	$ 31	$ 31 Low	All	☑	☑	☑	☑	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		$ 31 High	None																				

having roughly a 50/50 chance of occurring, is estimated to provide a total net return of $650 per acre in total or an average net return of $32.50 per acre over the 20-year horizon.

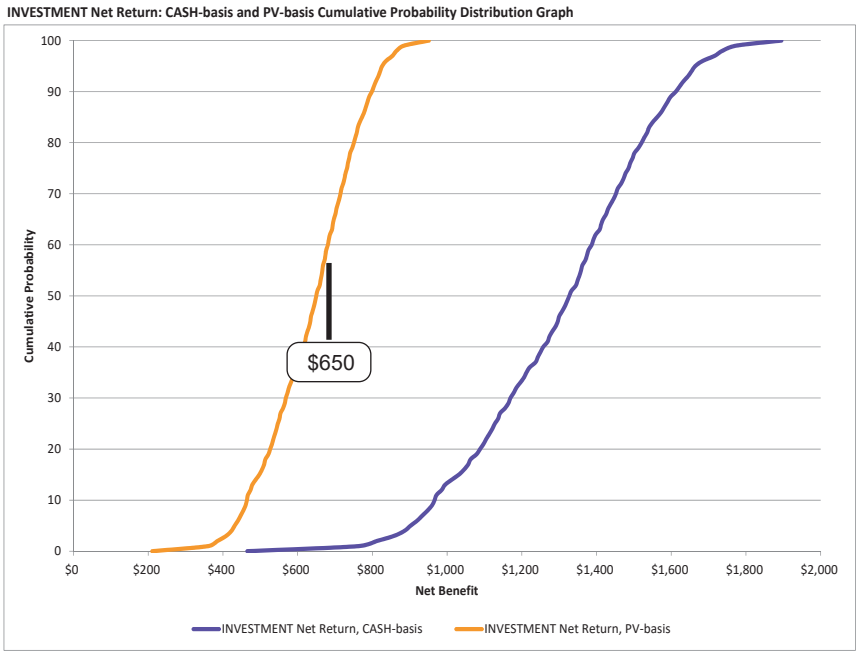
The highest net return the Riffs could expect on a NPV-basis would be a total of $950 per acre or an average of $47.50 yearly, while the lowest net return is estimated as $211 per acre or an average of $10.55 yearly. These results are important because they show the Riffs that there is a reasonable expectation that switching to a strip-till system could yield a positive net return over the proposed 20 year period. Based on the results, the Riffs decide to make the switch to strip-till, realizing that it should provide a return of at least $10.55/acre annually but may improve their returns on average by as much a $32.50/acre per year.

Further Considerations

There are additional aspects of the decision to switch to strip-till that the Riffs may also want to consider. These include making an estimate of the benefit gained from improved soil health due to increased organic matter and the subsequent reduction in fertilizer need over the long term. Quantifying these into per acre dollar values could further improve returns over time.

On the cost side, most operators find a guidance system is necessary to maintain accuracy, for both strip-till and planting. This additional cost could be included in further analysis. In addition, making a switch to reduced tillage and increasing the accuracy and effectiveness of each field pass can provide benefits through increased yields for many crops, especially during drought years. The potential increased yield is another area of additional return that could be included in the budget in order to further refine the cost/return projections over the next 20 years. Another set of costs the Riffs may need to consider are the management skills needed, both in the pre-plant stage, as post-planting and beyond.

Figure 1. MTRA per Acre Net Return for the Estimated Advantage of a Strip-till System over a Conventional Tillage System.



** The Riff Brothers' operation is a case study example created to demonstrate RightRisk tools and their applications. No identification with actual persons living or deceased, places, or agricultural operation is intended nor should be inferred.*