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Economics of Reduced Tillage in Sugar Beets

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Introduction

Sugarbeets are an important crop for farmers in the irrigated river valleys of Montana. Farmers along the Missouri, Yellowstone, Clarks Fork, and Big Horn rivers have been involved in sugar beet production for generations. In 2015, Montana growers produced 1.4 million tons of sugar beets on 43,700 acres, with an average yield of 33 tons per acre (USDA - NASS, 2016). The economic impact of beet production is considerable in rural communities and supports two processing facilities and associated employees; one in Billings and another in Sidney. It is important to the state and local economies that beet production continues to be successful and that all conservation efforts seek to provide positive benefits to the farmer, the beet industry, and the environment.

Historically, beets have been grown with considerable amounts of intensive tillage, often with 10 to 12 tillage operations to prepare the beds prior to seeding. This tillage leaves the soil vulnerable to wind erosion, especially during the peak wind season in winter and early spring. In addition, if a grower is using furrow irrigation, the soil is also eroded by the movement of water across the field, especially after a tillage event.

The USDA Natural Resources Conservation Service (NRCS) has classified the annual maximum soil loss tolerance (T) on most of these fields at 5 tons per acre per year, or about the thickness of a dime. However, when wind and water erosion are combined, soil losses may amount to 10 to 20 tons per acre every year in these systems, which is equivalent to 1/8 - 1/4 inch of topsoil loss every year. After 100 years, this can result in a soil loss of one to two feet.

Figure 1. Five tons of soil loss per acre per year is the equivalent to the thickness of a dime. Conventionally managed beet fields with furrow irrigation may be losing 10 to 20 tons per acre per year, equivalent to the stack of dimes on the left. After four to eight years, total soil loss will total one inch, equivalent to the stack of dimes on the right.

Unfortunately, what is lost to wind and water are the smallest particles of soil with the highest nutrients; organic matter, clay, and silt. It is often unfertile sand that is left behind.

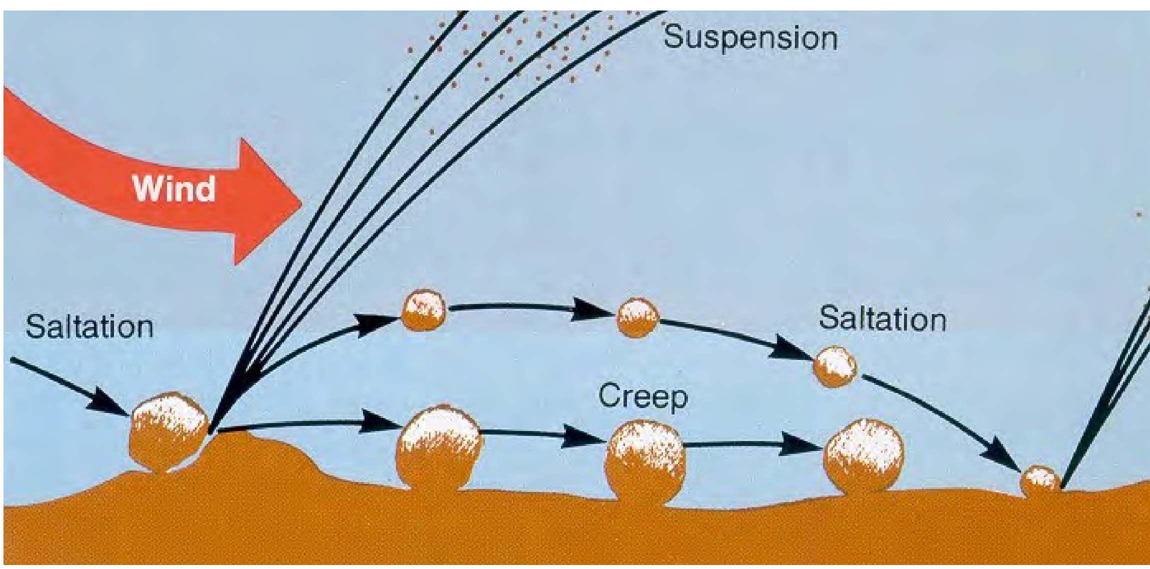

Figure 2. Wind erosion suspends and removes the lighter, fertile soil particles, leaving behind the heavier, less fertile soil particles (USDA - NRCS, 2011).

This fertility loss can be a significant financial loss. Jodi DeJongh and colleagues at the University of Minnesota and North Dakota State University analyzed six sugar beet farms in the Red River Valley and measured the soil accumulated in the ditch along with the fertilizer value in the soil (DeJong-Hughes, Franzen, and Wick, 2011). On average, they found each field had lost 9 tons per acre per year of topsoil, with an average fertilizer value of $55 per acre at 2014 fertilizer prices.

Figure 3. Soil accumulation in a ditch adjacent to a field with 40% residue in western Minnesota (DeJong-Hughes, Franzen, and Wick, 2011).

Figure 4. Soil accumulation in a ditch adjacent to a field with less than 10% residue one mile East of Figure 3 (DeJong-Hughes, Franzen, and Wick, 2011).

Table 1. Analysis of total nutrients and windblown soil collected in the field ditch (DeJong-Hughes, Franzen, and Wick, 2011).

	SOIL LOSS (T/AC)	TOTAL NITROGEN (LBS/AC)	TOTAL PHOSPHOROUS (LBS/AC)	TOTAL POTASSIUM (LBS/AC)
DITCH 1	2.6	10.3	3.2	8.0
DITCH 2	2.8	12.1	3.6	8.7
DITCH 3	1.6	8.4	1.9	4.9
DITCH 4	32.6	172.9	46.9	124.4
DITCH 5	5.5	23.5	7.2	18.0
DITCH 6	9.3	102.6	12.9	56.3
AVERAGE	**9.1**	**55.0**	**12.6**	**36.7**

In addition to the loss of fertility, the loss of soil organic matter leads to loss of tilth, soil structure, water infiltration and the loss of soil health. The benefits of soil organic matter are so substantial that it's difficult, if not impossible, to place a price on its value.

In March 2015, south-central Montana had a wind-storm with 70 mile-per-hour winds for 24 hours (Billings Gazette, 2015). This happened several days after beet farmers had begun re-shaping furrows that had settled over the winter, so many of these fields had been freshly tilled in the days prior. As a result, many beet fields blew out, filling ditches, and making road travel nearly impossible due to poor visibility.

Portions of Interstate 90 were closed due to hazardous driving conditions from the blowing dirt and smoke from a fire, and one highway fatality occurred due to low visibility. Afterwards, barley fields with young seedlings had to be replanted from the scouring damage.

This wind storm lead us at Montana NRCS to ask the question "How can we better serve our beet farmers and encourage reduced-tillage in beet systems?" This report is one attempt to help answer that question.

Figure 5. March 2015 wind storm near Billings. Photo courtesy of Larry Mayer, Billings Gazette.

Figure 6. Field after March 2015 wind storm near Billings. Photo courtesy of Larry Mayer, Billings Gazette.

Solutions

The current era of beet conservation is reminiscent of when no-till systems first became an option in dryland crop production 30 years ago. Farmers had to work out a lot of kinks and learn from each other. Thanks to their efforts, no-till is now the practice standard on at least 75 percent of our dryland farms in the state and dryland wind erosion has decreased substantially.

The introduction of Roundup Ready® sugarbeets in 2008 opened up new conservation opportunities for beet farmers, as deep tillage was no longer required for weed control. Since then, several farmers have been experimenting with reduced-tillage on their own farms. It is farmers, not government or academia that are leading the charge in learning what works best via trial-and-error.

One of the best ways to promote conservation in beet systems is to showcase farmers who are currently practicing conservation. In the summer of 2016, we visited with six beet farmers in various parts of Montana who have substantially cut back on tillage. Locations include Fromberg, Bridger, Hysham, Terry, Culbertson, and Hardin. These farmers all have different soils, irrigation systems, and crop rotations.

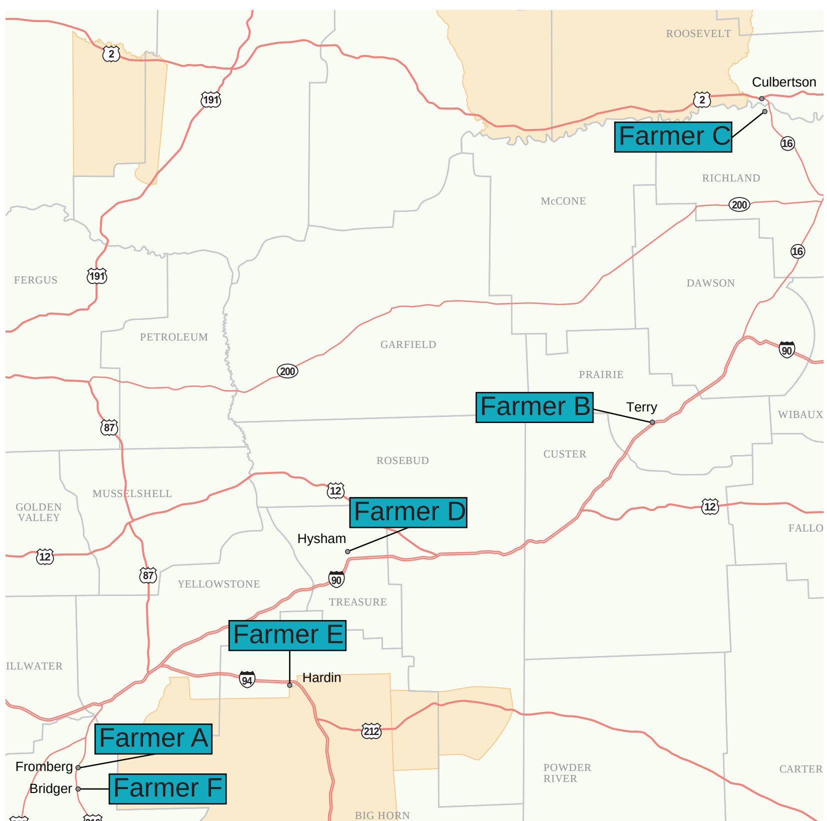

Figure 7. Farmer locations in Montana.

Management Comparisons

For each case study below, we give the complete field management operations for the entire operation, both “before” and “after” reduced tillage. Field operations are documented for the entire crop rotation, but economic analysis is only given for the beet year. Notice that each management system is labelled for each crop interval. A crop-interval is the time from one crop harvest to the next, and is different than a calendar year.

To maintain consistency, we have labelled each "before" rotation as "Conventional" and each "after" rotation as "Reduced-till". Because the beet harvest operation is full-width tillage of the field, beet production cannot technically be called "no-till." This presents some confusion in the case of Farmer D who uses three systems: conventional, strip-till, and reduced-till and is explained more fully in that section.

We made several assumptions in each case study. First, the irrigation system is the same for each farmer's conventional and reduced-till system. For example, Farmer A's conventional and reduced-till systems are under pivot irrigation, and Farmer B's conventional and reduced-till systems are both under furrow irrigation. Second, we assumed all systems were using Roundup Ready™ beets in order to have the same herbicide applications between the two.

In addition to field management details, we included several factors that NRCS uses to evaluate and rank Environmental Quality Incentives Program (EQIP) applications for funding. Each EQIP application is assigned points based on various national, state, and local priorities. Applications with higher ranking points are more competitive and more likely to receive funding than applications with lower ranking points. Ranking factors such as soil loss tolerance (T), Soil Tillage Intensity Rating (STIR), and Soil Conditioning Index (SCI) are determined by the Wind Erosion Prediction System (WEPS) software. WEPS is a computer model used by NRCS for planning purposes to compare various crop rotations.

Soil Loss Tolerance (T)

T is the maximum soil loss tolerance of a given soil series given as tons per acre per year. This is a number assigned by soil scientists as they classify the soil and is based on multiple factors such as profile depth, texture, rock fragments, and more. Values range from one to five tons per acre per year, with most beet fields being in the highest level of allowable soil loss of five tons per acre per year. For program application rankings, additional points are given to rotations that are under T.

Soil Tillage Intensity Rating (STIR)

NRCS assigns every field operation a STIR rating, which is a measure of the soil disturbance of a given implement. The following are STIR ratings for some typical beet operations:

WEPS adds up the STIR value of all the implements then divides by number of years in the rotation to calculate an average annual STIR value for the rotation. For program application ranking purposes, NRCS ranks applications based on the STIR value, with more points given for a lower STIR value.

Table 2. STIR values of various tillage implements

IMPLEMENT	STIR
DRILL, DOUBLE-DISK	6
LAND PLANE	10
CULTIVATOR, BETWEEN-ROW	10
DRILL, HOE-OPENERS	24
ROLLER HARROW	24
CULTIVATOR, 6-12 INCH SWEEPS	26
HEAVY DISK, OFFSET	39
SUBSOIL DISK RIPPER	58
MOLDBOARD PLOW	65

Soil Conditioning Index (SCI)

The Soil Conditioning Index (SCI) predicts the effect of management on soil organic matter and is calculated in WEPS by the following equation (USDA - NRCS, 2006):

$$SCI = OM + FO + ER$$

- OM (organic material) is the amount of organic material returned to the soil
- FO (field operations) is the intensity of tillage, which stimulates organic matter breakdown
- ER (erosion) is the amount of erosion in the rotation

SCI values generally range from -2 to +2, with 0 indicating organic matter inputs equal organic matter degradation. Negative values indicate that organic matter is degrading faster than inputs can replace it while positive values indicate an increasing organic matter trend. For contract ranking purposes, additional points are awarded to applications where the total SCI and OM sub factor of the improved management system are positive.

Innovation

Several farmers in this group are experimenting with innovative techniques, such as cover crops, incorporating livestock, and interseeding corn silage with soybeans. When information was available, we included it in each case study. However, no innovative techniques were included in the economic comparison in order to maintain a parallel comparison between conventional and reduced-till systems.

Disease Management

While disease management is beyond the scope of this report, it is important to mention that reduced-till systems require additional vigilance in managing for plant diseases, particularly Fusarium headblight in malt barley (Burrows, Grey, and Dyer, 2012). Reduced-till systems leave additional residue on the soil surface, which can harbor the disease. It should be noted that Fusarium lives only on grass crop residue, particularly corn, and is not carried on broadleaf crop residues. Care should be taken not to follow corn with malt barley in a reduced-till rotation.

Residue management and crop rotation are key components in managing disease as well as allowing for seedling establishment in the subsequent crop. Too much residue, if not managed properly, can reduce successful seedling establishment. Farmers will need to experiment with various residue levels when first starting out with a reduced-till system to determine what works best for their soil types, irrigation systems, and machinery.

Economic Comparisons

Each case study presents a partial-budget comparison of the conventional and reduced-till rotation only in the beet year, and not for the entire rotation. Partial budgets focus only on what has changed between each operation and are a great method to measure operating and ownership cost differences.

The economic partial-budget analysis only pertains to items that have changed within the operation – the savings shown is based on machinery ownership and operating cost. Inputs such as chemical and fertilizer use did not change with the change in management systems, therefore input costs were not used for this analysis. Likewise, we assumed constant yields between the two systems.

Enterprise Budget Generator

Enterprise Budget analysis software was used to conduct the economic analysis. This software was developed at the Montana State University Extension Service in Bozeman, Montana. The Enterprise Budget Generator is used to gain a full picture of a landowner's farm operation. It takes into account operating and ownership costs of each crop in the landowner's field operation.

Operating costs are variable costs that will be needed for the livelihood of the farm. In the case of this analysis, operating costs are calculated on the machinery used in each operation sequence. These costs include fuel, repairs, and lubrication. Ownership costs refer to the fixed costs associated with the farm operation. This includes depreciation, opportunity cost, insurance, and taxes.

Salvage value for most of the landowners' machinery is $0.00. This is in part because the machinery will be used until it is worn out. In the case a landowner had newer machinery and there is the possibility of trading the machinery in, salvage costs were calculated. Salvage value is an estimated value the landowner can receive when a machine is traded in for a newer model. Salvage values were calculated using guidance from the Iowa State University Extension and Outreach program.

Fuel cost is based on the machinery performance rate, how many acres per hour can be completed with that operation sequence, and is calculated within the budget generator. Performance rate information was given by the landowner. For this analysis, $3.00 was used for the diesel cost. This figure is an average of off-road diesel cost over the last five years in Montana.

Annual hours and annual acres used for each crop operation sequence is calculated within the budget software. However, labor costs are not included in the analysis. As mentioned earlier, input costs such as hired labor, chemical, and fertilizer costs are not included in the analysis.

Interpretation

Due to the variability of operations, it is probably more meaningful to compare the difference between the conventional and reduced-till operation of the same farmer, rather than compare the reduced-till operations among all of the farmers. Likewise, the percent cost savings between an individual farmer's systems may be more meaningful than the actual dollar amount savings, as machinery age and maintenance can influence the operating cost of production from one farm to the next. Also, note the time saved between each conventional and reduced-till operation. Time saved is only for the sugar beet year, not the entire rotation, and is not included in the total cost savings.

Farmer A – Carbon County

Table 3. Farmer A crop production.

CROP	ACRES IN 2016	YIELD
Sugar Beets	200	35 ton/ac
Malt Barley	400	130 bu/ac
Corn, Silage	400	40 ton/ac

Farmer A is located in Carbon County near the Clarks Fork River and has approximately 200 acres of sugar beets every year, with an average yield of 35 tons per acre. In addition to growing crops, Farmer A operates a beef cattle feedlot.

He grows all of his beets with a reduced-till system and uses both pivot and flood irrigation systems. For this case study, the rotation comparisons assume a pivot irrigation system. In a furrow irrigation system, Farmer A would use a row cleaner, or ditcher, prior to irrigation of corn and beets in both conventional and reduced-till systems. This is a light operation that cleans out the furrows every 22 inches for improved water flow.

Figure 8. Farmer A's reduced-till beets and malt barley under pivot irrigation, July 2015.

For the purposes of this report, we assumed Farmer A was planting his corn silage with a planter on 24-inch spacings with a population of 43,000 to 45,000 seeds per acre. This is the majority practice on most of his silage acres. However, Farmer A has also been experimenting with interseeding soybeans on his corn silage on a small portion of his silage acres (USDA - NRCS MT, 2015). For the interseeding, he uses his air seeder to plant corn silage on 15-inch spacings at a population of 48,000 to 55,000 seeds per acre. He then interseeds soybeans between the corn rows at a population of 104,000 to 120,000 seeds per acre. He finds that the soybeans add nitrogen to the soil at an estimated valued of $20-$30 per acre. The soybeans also add extra protein and tonnage to his silage, with the extra tonnage estimated at one to two tons per acre. Farmer A is only trying this practice under pivot irrigation, as furrow irrigation does not allow for interseeding between the rows.

Figure 9. Farmer A's corn silage with interseeded soybeans, July 2015.

Farmer A has also been experimenting with adding an additional forage crop in his rotation, planting after barley harvest, about August 15th. The additional forage yields about three tons per acre and is worth about $135 per ton in his cattle feeder operation. For this economic analysis, we did not include the additional forage crop in order to keep the comparison as straightforward as possible.

See Tables 9 and 10 below for sugar beet operation sequences. Everything except the fertilizer application was used in the analysis, as it is custom hired. Farmer A owns all his equipment.

Based on calculations using the enterprise budget software, the ownership and operating costs of the conventional system is $206.30 per acre, with $104.80 per acre in operating costs and $101.50 per acre in ownership costs.

The total cost of the reduced-till system is $109.90, with the estimated operating cost at $52.03 per acre and the estimated ownership costs at $57.87 per acre.

When comparing reduced-till with the conventional tilled system, there is a savings of $96.40 per acre, or about 47 percent. Likewise, Farmer A is saving 205 hours of labor every year, or roughly one hour of labor savings for every acre of sugar beets.

Farmer A has been able to dramatically increase the acres he farms by using a reduced-till system due to time and cost savings. In the conventional system, he estimates he put 6,000-8,000 hours per year on his equipment across 600 crop acres. With reduced tillage he estimates he is putting 500 hours per year on his equipment across 1,400 crop acres. In addition to decreasing the wear and tear on his equipment, Farmer A is significantly extending the useful life of his machinery.

Table 9. Farmer A Conventional operations

	DATE	OPERATION
BEETS	YR 1 Sept. 13	Heavy Disk
	YR 1 Sept. 14	Disk ripper
	YR 1 Sept. 15	Roller harrow
	YR 1 Sept. 16	Roller harrow
	YR 1 Sept. 17	Land plane
	YR 1 Sept. 18	Land plane
	YR 1 Sept. 19	Fertilizer
	YR 1 Sept. 20	Roller harrow
	YR 1 Oct. 25	Ridger
	YR 2 Mar. 31	Ridger
	YR 2 April 16	Plant beets, double-disk opener
	YR 2 May 16	Spray herbicide
	YR 2 June 1	Start irrigation
	YR 2 June 16	Spray herbicide
	YR 2 Sept. 1	Stop irrigation
	YR 2 Oct. 2	Harvest beets
BARLEY	YR 2 Oct. 10	Heavy disk
	YR 2 Oct. 11	Heavy disk
	YR 2 Oct. 12	Fertilizer
	YR 2 Oct. 13	Roller harrow
	YR 3 Mar. 28	Fertilizer
	YR 3 April 1	Drill barley
	YR 3 May 20	Spray herbicide, fungicide, insecticide
	YR 3 June 1	Start irrigation
	YR 3 July 15	Stop irrigation
	YR 3 Aug. 10	Harvest barley
CORN SILAGE	YR 3 Aug. 11	Bale straw
	YR 3 Aug. 12	Spread manure
	YR 3 Aug. 13	Heavy disk
	YR 3 Aug. 14	Disk ripper
	YR 3 Aug. 15	Roller harrow
	YR 3 Aug. 16	Roller harrow
	YR 3 Aug. 17	Land plane
	YR 3 Aug. 18	Land plane
	YR 3 Sept. 5	Fertilizer
	YR 3 Sept. 6	Roller harrow
	YR 3 Oct. 25	Ridger
	YR 4 Mar. 31	Ridger
	YR 4 May 5	Plant corn silage
	YR 4 May 7	Spray herbicide
	YR 4 June 1	Spray herbicide
	YR 4 June 15	Start irrigation
	YR 4 Sept. 1	Stop irrigation
	YR 4 Sept. 10	Harvest corn silage

Table 10. Farmer A Reduced-till operations

	DATE	OPERATION
BEETS	YR 1 Sept. 30	Fertilizer
	YR 1 Oct. 15	Heavy harrow
	YR 1 Oct. 16	Irrigation, 1 inch
	YR 2 April 16	Plant beets, double-disk opener
	YR 2 May 16	Spray herbicide
	YR 2 June 1	Start irrigation
	YR 2 June 16	Spray herbicide
	YR 2 Sept. 1	Stop irrigation
	YR 2 Oct. 4	Harvest beets
BARLEY	YR 2 Oct. 10	Heavy harrow
	YR 3 Feb. 28	Fertilizer
	YR 3 April 1	Drill barley
	YR 3 May 20	Spray herbicide, fungicide, insecticide
	YR 3 June 1	Start irrigation
	YR 3 July 15	Stop irrigation
	YR 3 Aug. 10	Harvest barley
CORN SILAGE	YR 3 Aug. 11	Bale straw
	YR 3 Aug. 12	Spread manure
	YR 4 Mar. 5	Fertilizer
	YR 4 May 5	Plant corn silage
	YR 4 May 7	Spray herbicide
	YR 4 June 1	Start irrigation
	YR 4 June 15	Spray herbicide
	YR 4 Sept. 1	Stop irrigation
	YR 4 Sept. 10	Harvest corn silage

Conservation Factors

Soil type: Loam
Soil loss tolerance: 5 tons/acre/year

Conventional Operations
Average annual soil loss: 3.4 tons/acre/year
STIR: 170
SCI: 1.2

Reduced-till Operations
Average annual soil loss: 0 tons/acre/year
STIR: 18
SCI: 1.7

Table 11. Farmer A partial budget analysis.

REDUCED TILLAGE	OPERATING	OWNERSHIP	TOTAL		ACRES	HOURS	HOURS/ ACRE	ACRES/ HOUR
Planter	10.91	9.40	20.31		200	25	0.13	8
Defoliator	12.93	11.43	24.36		200	135	0.68	1
Digger	22.88	27.93	50.81		200	131	0.66	2
Heavy Harrow	2.91	5.98	8.89		200	9	0.05	22
Sprayer	2.40	3.13	5.53		400	5	0.01	80
Total	**$52.03**	**$57.87**	**$109.90**			**305**		
CONVENTIONAL TILLAGE	**OPERATING**	**OWNERSHIP**	**TOTAL**		**ACRES**	**HOURS**	**HOURS/ ACRE**	**ACRES/ HOUR**
Tandem Disk	9.22	9.81	19.03		200	20	0.10	10
Disk Ripper	11.55	9.17	20.72		200	45	0.23	4
Planter	10.91	9.40	20.31		200	25	0.13	8
Defoliator	12.93	11.43	24.36		200	135	0.68	1
Digger	22.88	27.93	50.81		200	131	0.66	2
Roller Harrow	15.91	15.52	31.43		600	60	0.10	10
Land Plane	9.82	9.14	18.96		400	44.5	0.11	9
Ridger	9.18	5.35	14.53		400	44.5	0.11	9
Sprayer	2.40	3.75	6.15		400	5	0.01	80
Total	**$104.80**	**$101.50**	**$206.30**			**510**		
SAVINGS	**OPERATING**	**OWNERSHIP**	**TOTAL**		**ACRES**	**HOURS**	**HOURS/ ACRE**	**ACRES/ HOUR**
Total	**$52.77**	**$43.63**	**$96.40**		**200**	**205**	**1**	
Percent savings			**47%**					


Figure 10. Farmer A reduced-till beet, July 2015.


Figure 11. Soil from Farmer A's reduced-till field.

FARMER B – Prairie County

Table 12. Farmer B crop production.

CROP	ACRES IN 2016	YIELD
Sugar beets	205	34 ton/ac
Corn silage	250	30 ton/ac
Spring wheat	80	60 bu/ac
Alfalfa	50	4 ton/ac
Soybeas	10	Hayed this year

Farmer B is located in Prairie County, near Terry, Montana and has approximately 205 acres of sugar beets every year, with an average yield of 34 tons per acre and sugar content of 18-25 percent. Recently, Farmer B was honored as a top producer by his local beet cooperative. This farmer switched to reduced-tillage in 2003. Prior to reducing tillage, his ground was lumpy and hard in the fall. He liked the way that reduced-till mellowed out the soil. He can harvest beets 1 to 1.5 days earlier than his conventional neighbors after a rain. In addition, he is able to keep on harvesting longer during a rain than before. He attributes this difference to increased soil organic matter. His current soil organic matter is about 2.5 percent and on an upward trend.

In addition, Farmer B had a labor shortage and needed to reduce the time he spent in the field. Looking back, he doesn't know how he and his family used to do it all. The numbers reflect this time saving. Farmer B is saving 383 hours per year in beet production alone. This works out to about 1.8 hours per acre of time savings, the largest margin among farmers surveyed for this report.

See Tables 13 and 14 below for sugar beet operation sequence. Everything except the fertilizer application was used in the analysis. Landowner B owns all machinery involved in the sugar beet operation. The fertilizer application is custom hired.

Based on calculations using the enterprise budget software, as a conventional tillage producer, it is estimated Farmer B has an average of $123.72 per acre operating cost and an estimated $38.50 per acre ownership cost. This gives a total of $162.22 per acres cost to grow conventional sugar beets.

When Farmer B converted to a reduced tillage management system, it is assumed there is an overall cost of $82.32 per acre. The estimated operating cost totaled $50.10 per acre and the ownership costs are estimated at $32.22 per acre.

As a result, Farmer B is saving about $80 per acre, or 49 percent of his total operating and ownership costs. This agrees with his reported fuel savings. Prior to reduced-tillage, he used about 10,000 gallons of diesel per year. Now he uses 6,000 gallons of diesel per year.

Table 13. Farmer B Conventional operations

	DATE	OPERATION
BEETS	YR 1 Aug. 15	Bale straw
	YR 1 Oct. 20	Disk, offset heavy
	YR 1 Oct. 21	Moldboard plow
	YR 1 Oct. 22	Roller harrow
	YR 1 Oct. 23	Roller harrow
	YR 1 Oct. 24	Land plane
	YR 1 Oct. 25	Broadcast fertilizer
	YR 1 Oct. 26	Cultivator, Vibrashank
	YR 1 Oct. 27	Bed shaper
	YR 2 April 15	Plant beets, double-disk opener
	YR 2 May 10	Spray herbicide
	YR 2 May 11	Cultivate
	YR 2 May 20	Spray herbicide
	YR 2 May 25	Cultivate between rows
	YR 2 May 30	Spray herbicide
	YR 2 June 15	Furrow shaper
	YR 2 June 20	Start furrow irrigation
	YR 2 Sept. 1	Stop furrow irrigation
	YR 2 Oct. 5	Harvest beets
CORN SILAGE	YR 2 Oct. 20	Subsoiler
	YR 2 Oct. 21	Roller harrow
	YR 3 May 1	Broadcast fertilizer
	YR 3 May 3	Cultivator, Vibrashank
	YR 3 May 5	Plant corn, double-disk opener
	YR 3 June 5	Spray herbicide
	YR 3 June 7	Cultivate between rows
	YR 3 June 20	Furrow shaper
	YR 3 June 25	Start furrow irrigation
	YR 3 Aug. 15	Stop furrow irrigation
	YR 3 Sept. 10	Harvest corn silage
SPRING WHEAT	YR 3 Oct. 20	Disk, offset heavy
	YR 4 Mar. 30	Broadcast fertilizer
	YR 4 April 1	Cultivator, Vibrashank
	YR 4 April 10	Drill spring wheat, double-disk opener
	YR 4 May 15	Spray herbicide
	YR 4 June 25	Start flood irrigation
	YR 4 July 10	Stop flood irrigation
	YR 4 Aug. 15	Harvest spring wheat

Table 14. Farmer B Reduced-till operations

	DATE	OPERATION
BEETS	YR 1 Aug. 15	Bale straw
	YR 1 Aug. 20	Chisel plow
	YR 1 Oct. 20	Broadcast fertilizer
	YR 1 Oct. 21	Furrow shaper
	YR 2 April 15	Plant beets, double-disk opener
	YR 2 May 1	Spray herbicide
	YR 2 May 15	Spray herbicide
	YR 2 June 10	Furrow shaper
	YR 2 June 12	Start furrow irrigation
	YR 2 Sept. 5	Stop furrow irrigation
	YR 2 Oct. 5	Harvest beets
CORN SILAGE	YR 2 Oct. 20	Chisel plow
	YR 3 April 15	Broadcast fertilizer
	YR 3 April 20	Cultivator, Vibrashank
	YR 3 April 25	Plant corn silage, double-disk opener
	YR 3 May 15	Spray herbicide
	YR 3 June 1	Spray herbicide
	YR 3 June 15	Furrow shaper
	YR 3 June 16	Start furrow irrigation
	YR 3 Aug. 15	Stop furrow irrigation
	YR 3 Sept. 10	Harvest corn silage
SPR WHEAT	YR 4 April 5	Drill spring wheat, double-disk opener
	YR 4 April 26	Spray herbicide
	YR 4 June 1	Start flood irrigation
	YR 4 July 1	Stop flood irrigation
	YR 4 Aug. 15	Harvest spring wheat

Conservation Factors

Soil type: Silty clay
Soil Loss Tolerance (T): 5 tons/acre/year

Conventional Operations
Average annual soil loss: 11.3 tons/acre/year
STIR: 133
SCI: -0.6

Reduced-till Operations
Average annual soil loss: 0 tons/acre/year
STIR: 50
SCI: 0.8

Table 15. Farmer B partial budget analysis.

REDUCED TILLAGE	OPERATING	OWNERSHIP	TOTAL	ACRES	HOURS	HOURS/ ACRE	ACRES/ HOUR
Planter	8.88	8.55	17.43	205	34	0.17	6
Furrow Shaper	6.67	2.95	9.62	205	34	0.17	6
Defoliator	8.28	5.57	13.85	205	68.5	0.33	3
Digger	12.03	7.09	19.12	205	68	0.33	3
Chisel Plow	9.03	2.09	11.12	410	41	0.10	10
Sprayer	5.21	5.98	11.19	410	16.3	0.04	25
Total	**$50.10**	**$32.23**	**$82.33**		**261.8**		
CONVENTIONAL TILLAGE	**OPERATING**	**OWNERSHIP**	**TOTAL**	**ACRES**	**HOURS**	**HOURS/ ACRE**	**ACRES/ HOUR**
Planter	10.28	6.74	17.02	205	34	0.17	6
Furrow Shaper	8.12	3.59	11.71	410	68	0.17	6
Defoliator	8.93	5.34	14.27	205	68.5	0.33	3
Digger	12.03	7.09	19.12	205	68	0.33	3
Cultivator	15.45	2.12	17.57	615	112	0.18	5
Baler	6.88	6.05	12.93	205	45	0.22	5
Off-set Disk	14.62	1.38	16.00	205	68	0.33	3
Moldboard Plow	15.18	2.37	17.55	205	68	0.33	3
Roller Harrow	14.59	1.30	15.89	410	68.5	0.17	6
Land Plane	14.26	1.52	15.78	205	20	0.10	10
Sprayer	3.40	1.00	4.40	615	24.4	0.04	25
Total	**$123.74**	**$38.50**	**$162.24**		**644.4**		
SAVINGS	**OPERATING**	**OWNERSHIP**	**TOTAL**	**ACRES**	**HOURS**	**HOURS/ ACRE**	**ACRES/ HOUR**
Total	**$73.64**	**$6.27**	**$79.91**	**205**	**382.6**	**1.8**	
Percent savings			**49%**				

FARMER C – Richland County

Table 16. Farmer C crop production.

CROP	ACRES IN 2016	YIELD
Sugar beets	100	28 ton/ac
Spring wheat or durum	100	75-80 bu/ac

Farmer C has approximately 100 acres of sugar beets ever year, with an average yield of 28 tons per acre. This farmer has practiced reduced-tillage since he started beet farming in 2008 and did not use a prior conventional system. The conventional system listed here for comparison reflects what most conventional beet farmers practice in Richland County.

Farmer C grows beets every other year. He uses flood irrigation and runs two sets with border-dikes every 60 feet. In dry years, he will do three irrigation sets, which is about 20 percent of the time. Most of his neighbors do three irrigation sets in a normal year. Farmer C believes that reduced-tillage has allowed him to cut down from three to two irritation sets most years.

Figure 12. Reduced-till beets with flood irrigation, June 2016. Notice the flood ditch is parallel to beet row direction, with water travel perpendicular to beet rows.

Wheat residue management is key for a successful beet crop the next year. He keeps tall standing stubble (12-18 inches) and does not bale or burn the residue. He uses a straw chopper on his combine that distributes the straw the entire width of the header pass. Farmer C uses a JD 1730 planter for his beets with floating row cleaners with a depth gauge.

Figure 13 (left). NRCS staff with row cleaners on drill, June 2016.
Figure 14 (right). Schlagel closing wheel on planter, June 2016. Farmer C believes this type of wheel is better than types made of solid rubber or metal in order to crumble the sidewalls and avoid sidewall compaction.

Before 2015, he did nothing after beet harvest to smooth the ground. But now he is having problems with the old beet holes remaining in the field. He finds that running a chisel plow with a coil-tine harrow about one inch deep gets rid of the divots.

2016 was an incredibly wet harvest season, with five inches of rain falling in October. It's the worst harvest season he's had for field conditions. As a result, the beet fields were very torn up after harvest and he had to do some deep tillage this fall, which made his operating costs about 50 percent more expensive in 2016. He does think he will have to do some land-planing next spring, but is hopeful that this is a rare occurrence, as the last time this much rain came in October was in 1998.

See Tables 17 and 18 below for sugar beet operation sequence. Everything except the fertilizer application was used in the analysis. The fertilizer application is custom hired. Farmer C owns all machinery involved in the sugar beet operation.

Based on calculations using the enterprise budget software, the ownership and operating costs of the conventional system is $243.22 per acre, with $188.69 per acre in operating costs and $54.53 per acre in ownership costs.

The total cost of the reduced-till system is $92.60, with the estimated operating cost at $65.33 per acre and the estimated ownership costs at $27.27 per acre.

When comparing reduced-till with the conventional tilled system, there is a savings of $150.62 per acre, or about 62 percent. This is the largest percentage savings among the farmers surveyed for this report. Likewise, Farmer C is saving 136 hours of labor every year, or roughly 1.4 hours of labor savings for every acre of sugar beets.

Table 17. Farmer C Conventional operations

	DATE	OPERATION
BEETS	YR 1 Aug. 20	Bale straw
	YR 1 Sept. 9	Subsoil disk ripper
	YR 1 Sept. 10	Disk, tandem heavy
	YR 1 Sept. 12	Roller harrow
	YR 1 Sept. 15	Bed shaper
	YR 2 April 10	Fertilizer injection
	YR 2 April 10	Roller, on beds
	YR 2 May 7	Plant beets, double-disk opener with starter fertilizer
	YR 2 May 8	Spray herbicide and insecticide
	YR 2 June 5	Spray herbicide
	YR 2 June 10	Broadcast fertilizer
	YR 2 June 15	Start flood irrigation
	YR 2 July 1	Spray herbicide
	YR 2 Aug. 1	Stop flood irrigation
	YR 2 Oct. 1	Harvest beets
SPRING WHEAT	YR 2 Oct. 15	Disk, tandem heavy
	YR 3 April 15	Disk, tandem heavy
	YR 3 April 17	Disk, tandem light
	YR 3 April 19	Disk, tandem light
	YR 3 April 30	Broadcast fertilizer
	YR 3 May 2	Spray herbicide
	YR 3 May 5	Drill springwheat, hoe openers
	YR 3 May 28	Broadcast fertilizer
	YR 3 June 1	Spray herbicide and fungicide
	YR 3 June 2	Start flood irrigation
	YR 3 July 2	Stop flood irrigation
	YR 3 Aug. 20	Harvest spring wheat

Table 18. Farmer C Reduced-till operations

	DATE	OPERATION
BEETS	YR 1 Sept. 23	Spray herbicide
	YR 1 Oct. 5	Graze
	YR 2 April 10	Fertilizer injection
	YR 2 May 7	Plant beets, double-disk opener with starter fertilizer
	YR 2 May 8	Spray herbicide and insecticide
	YR 2 June 5	Spray herbicide
	YR 2 June 10	Broadcast fertilizer
	YR 2 June 15	Start flood irrigation
	YR 2 July 1	Spray herbicide
	YR 2 Aug. 1	Stop flood irrigation
	YR 2 Oct. 1	Harvest beets
SPRING WHEAT	YR 2 Oct. 15	Chisel plow at 1” depth with coil tine harrow
	YR 3 May 1	Drill spring wheat, single-disk opener with starter fertilizer
	YR 3 May 2	Spray herbicide
	YR 3 May 28	Broadcast fertilizer
	YR 3 June 1	Spray herbicide and fungicide
	YR 3 June 2	Start flood irrigation
	YR 3 July 2	Stop flood irrigation
	YR 3 Aug. 20	Harvest spring wheat

Conservation Factors

Soil type: Silty clay loam
Soil loss tolerance: 5 tons/acre/year

Conventional Operations
Average annual soil loss: 3.1 tons/acre/year
STIR: 157
SCI: -0.2

Reduced-till Operations
Average annual soil loss: trace
STIR: 21
SCI: 0.9

Table 19. Farmer C partial budget analysis.

REDUCED TILLAGE	OPERATING	OWNERSHIP	TOTAL	ACRES	HOURS	HOURS/ ACRE	ACRES/ HOUR
Sprayer	10.00	10.00	20.00	400	5	0.08	80
Planter	11.81	7.52	19.33	100	10	0.10	10
Defoliator	22.23	5.27	27.50	100	40.5	0.41	2
Digger	21.29	4.48	25.77	100	34	0.34	3
Total	**$65.33**	**$27.27**	**$92.60**		**89.5**		
CONVENTIONAL TILLAGE	**OPERATING**	**OWNERSHIP**	**TOTAL**	**ACRES**	**HOURS**	**HOURS/ ACRE**	**ACRES/ HOUR**
Planter	18.56	11.24	29.80	100	14	0.14	7
Roller	14.38	2.43	16.81	100	22	0.22	5
Defoliator	17.84	5.31	23.15	100	40	0.40	3
Digger	17.67	5.17	22.84	100	39	0.39	3
Roller Harrow	17.12	3.06	20.18	100	7	0.07	15
Subsoiler	14.51	6.47	20.98	100	20	0.20	5
Land Plane	12.17	0.72	12.89	100	6.5	0.07	15
Cultivator	17.59	3.46	21.05	100	10	0.10	10
Bed Shaper	16.4	2.46	18.86	100	5	0.05	20
Disk Ripper	18.31	4.05	22.36	100	25	0.25	4
Sprayer	7.50	7.50	15.00	300	3.75	0.24	80
Tandem Disk	16.64	2.66	19.30	100	33	0.33	3
Total	**$188.69**	**$54.53**	**$243.22**		**225**		
SAVINGS	**OPERATING**	**OWNERSHIP**	**TOTAL**	**ACRES**	**HOURS**	**HOURS/ ACRE**	**ACRES/ HOUR**
Total	**$123.36**	**$27.26**	**$150.62**	**100**	**135.5**	**1.4**	
Percent savings			**62%**				

FARMER D – Treasure County

Table 20. Farmer D crop production.

CROP	ACRES IN 2016	YIELD
Sugar beets	450	30 ton/ac
Corn, grain	300	200 bu/ac
Wheat, spring	500	90 bu/ac

Farmer D is located in Treasure County and has approximately 450-500 acres of sugar beets every year, with an average yield of 30 tons per acre and sugar content of 17.5 percent. He has both flood and pivot irrigation systems. Farmer D practices conventional tillage on his flood irrigated fields. Farmer D practices both strip-tillage and an "almost no-till system" of flat-planted beets on his pivot irrigated fields. However, for purposes of this case study, we will only compare his conventional system with his strip-till system.

In 2008, Farmer D bought a 16-row Orthman strip-till implement that tills in 22-inch strips and has both dry and liquid fertilizer banding potential. He thinks his strip-till yields are similar to conventional beet production and better than his "almost no-till" system. In the "almost no-till" system he fights through the grain straw when planting to get a good stand of beets. He thinks this can decrease his beet yield by 5 tons per acre. In general, he expects 5-10 percent less yield from his "almost no-till" system, compared with his strip-till system. But he cautions that strip-till can be a problem if the planter isn't accurately aligned with the middle of the strip.

Figure 15. Farmer D's residue in the spring after beet harvest, March 2015.

Farmer D leaves all corn stover and wheat straw on the field after both grain harvests. In order to help break down this residue, he has added yellow grain peas to his rotation between the corn and wheat. The lower carbon to nitrogen ratio in the pea crop helps break down his corn residue faster. Adding a broadleaf crop to the rotation may be one tool in the disease management toolbox for other farmers concerned about corn residue harboring Fusarium headblight and damaging malt barley quality, as the disease is only carried on grass crop residues.

See Tables 21 and 22 below for sugar beet operation sequence. Everything except the fertilizer application was used in the analysis. The fertilizer application is custom hired. Farmer D owns all machinery involved in the sugar beet operation. Machinery was newer so it is assumed there will be a salvage value associated with the machinery. The salvage value was calculated using the Iowa State University Extension and Outreach- Estimating Farm Machinery Cost article.

Based on calculations using the enterprise budget software, the ownership and operating costs of the conventional system is $226.70 per acre, with $122.05 per acre in operating costs and $104.65 per acre in ownership costs.

The total cost of the strip-till system is $161.18, with the estimated operating cost at $81.77 per acre and the estimated ownership costs at $79.41 per acre.

When comparing the strip-till system with the conventional tilled system, there is a saving of $65.52 per acre, or about 29 percent. Likewise, with strip-till, Farmer D is saving 366 hours of labor every year, or roughly 0.8 hours of labor savings for every acre of sugar beets.

Table 21. Farmer D Conventional operations

	DATE	OPERATION
BEETS	YR 1 Aug. 3	Subsoil disk ripper
	YR 1 Aug. 7	Roller harrow
	YR 1 Aug. 9	Roller harrow
	YR 1 Aug. 25	Land plane
	YR 1 Aug. 27	Land plane
	YR 1 Aug. 29	Land plane
	YR 1 Aug. 31	Broadcast fertilizer
	YR 1 Sept. 4	Cultivator (Kongskilde Triple K, S-harrow)
	YR 1 Sept. 30	Bed shaper
	YR 2 April 4	Plant beets, double-disk opener
	YR 2 May 1	Spray insecticide
	YR 2 May 15	Spray herbicide
	YR 2 May 20	Cultivator, between-row
	YR 2 May 30	Inject liquid fertilizer
	YR 2 June 1	Spray herbicide
	YR 2 June 15	Start furrow irrigation
	YR 2 Sept. 1	Stop furrow irrigation
	YR 2 Oct. 2	Harvest beets
GRAIN CORN	YR 2 Nov. 1	Subsoil disk ripper
	YR 2 Nov. 3	Roller harrow
	YR 2 Nov. 5	Land plane
	YR 2 Nov. 7	Lanc plane
	YR 2 Nov. 9	Broadcast fertilizer
	YR 2 Nov. 11	Cultivator (Kongskilde Triple K, S-harrow)
	YR 3 April 20	Plant corn, double-disk opener with starter fertilizer
	YR 3 April 25	Spray herbicide
	YR 3 April 25	Spray herbicide
	YR 3 May 30	Side-dress liquid fertilizer
	YR 3 June 4	Cultivator, between-row
	YR 3 June 15	Start furrow irrigation
	YR 3 Sept. 15	Stop furrow irrigation
	YR 3 Oct. 31	Harvest grain corn
SPR WHEAT	YR 4 Mar. 15	Drill spring wheat, single-disk opener
	YR 4 May 5	Broadcast fertilizer
	YR 4 May 14	Spray herbicide
	YR 4 May 15	Start furrow irrigation
	YR 4 June 15	Stop furrow irrigation
	YR 4 July 20	Harvest spring wheat

Table 22. Farmer D Strip-till operations

	DATE	OPERATION
BEETS	YR 1 Aug. 30	Heavy harrow
	YR 1 Aug. 31	Heavy harrow
	YR 1 Sept. 15	Strip-till bed conditioner
	YR 1 Sept. 16	Smooth roller
	YR 1 Oct. 1	Spray herbicide
	YR 2 April 4	Plant beets, double-disk opener
	YR 2 May 1	Spray herbicide and insecticide
	YR 2 May 15	Spray herbicide
	YR 2 May 30	Inject liquid fertilizer
	YR 2 June 1	Spray herbicide
	YR 2 June 15	Start pivot irrigation
	YR 2 Sept 1	Stop pivot irrigation
	YR 2 Oct. 2	Harvest beets
GRAIN CORN	YR 2 Oct. 15	Heavy harrow
	YR 2 Oct. 20	Heavy harrow
	YR 3 April 20	Plant corn, double-disk opener with starter fertilizer
	YR 3 April 25	Spray herbicide
	YR 3 May 30	Spray herbicide
	YR 3 June 15	Start pivot irrigation
	YR 3 Sept. 15	Stop pivot irrigation
	YR 3 Oct. 31	Harvest grain corn
SPR WHEAT	YR 4 Mar. 15	Drill spring wheat, single-disk opener
	YR 4 May 5	Broadcast fertilizer
	YR 4 May 14	Spray herbicide
	YR 4 May 15	Start pivot irrigation
	YR 4 June 15	Stop pivot irrigation
	YR 4 July 20	Harvest spring wheat

Conservation Factors

Soil type: Clay loam
Soil loss tolerance (T): 5 tons/acre/year

Conventional Operations
Average wind erosion loss: 5.9 tons/acre/year
STIR: 98
SCI: 0.1

Strip-till Operations
Average wind erosion loss: 0.1 tons/acre/year
STIR: 31
SCI: 0.8

Table 23. Farmer D partial budget analysis.

STRIP- TILLAGE	OPERATING	OWNERSHIP	TOTAL		ACRES	HOURS	HOURS/ ACRE	ACRES/ HOUR
Planter	14.17	15.03	29.20		450	34	0.08	13
Roller	6.19	7.02	13.21		450	11	0.02	41
Defoliator	13.6	11.79	25.39		450	182	0.40	2
Digger	26.49	25.18	51.67		450	177	0.39	3
Heavy Harrow	8.86	9.04	17.90		900	22.5	0.03	40
Bed Conditioner	9.53	10.35	19.88		450	45	0.10	10
Sprayer	2.93	1.00	3.93		1800	30	0.02	60
Total	**$81.77**	**$79.41**	**$161.18**			**501.5**		
CONVENTIONAL TILLAGE	**OPERATING**	**OWNERSHIP**	**TOTAL**		**ACRES**	**HOURS**	**HOURS/ ACRE**	**ACRES/ HOUR**
Planter	14.68	13.81	28.49		450	64	0.14	7
Roller	6.70	5.33	12.03		450	11	0.02	41
Defoliator	14.11	10.57	24.68		450	182	0.40	2
Digger	28.06	25.39	53.45		450	177	0.39	3
Roller Harrow	8.27	6.11	14.38		900	60	0.07	15
Subsoiler	17.49	16.38	33.87		450	89	0.20	5
Land Plane	7.14	4.98	12.12		2250	149.5	0.07	15
Cultivator	13.02	11.8	24.82		900	90	0.10	10
Bed Shaper	10.39	9.44	19.83		450	22.5	0.05	20
Sprayer	2.19	0.84	3.03		1350	22.5	0.02	60
Total	**$122.05**	**$104.65**	**$226.70**			**867.5**		
SAVINGS	**OPERATING**	**OWNERSHIP**	**TOTAL**		**ACRES**	**HOURS**	**HOURS/ ACRE**	**ACRES/ HOUR**
Total	**$40.28**	**$25.24**	**$65.52**		**450**	**366**	**0.81**	
Percent savings			**29%**					

FARMER E – Big Horn County

Table 24. Farmer E crop production.

CROP	ACRES IN 2016	YIELD
Sugar beets	380	30 ton/ac
Malt barley	600	115 bu/ac

Farmer E is located in Big Horn County and grows about 380 acres of sugar beets each year. His rotation is usually beets-barley-barley. The majority of his irrigation is a flood system. Farmer E's silty clay soils have little slope and the flood irrigation water can pond. This presents unique challenges in Big Horn County, where summer temperatures can exceed 100ºF. If ponding happens on a hot day, his beets are damaged from over-exposure to hot water. As a result, Farmer E has to irrigate most of his reduced-till fields at night to avoid "cooking" the beets. Farmer E also finds that strip-till is too difficult on his heavy soils.

Of the six farmers surveyed, Farmer E had the least management difference between his reduced-till and conventional tillage operations. This may be due to his challenging soils and topography. As a result, Farmer E also had the least difference in cost savings between the two systems.

See Table 25 and 26 below for sugar beet operation sequence. Everything except the fertilizer application was used in the analysis. The fertilizer application is custom hired. Farmer E owns all machinery involved in the sugar beet operation. Machinery was newer so it is assumed, there will be a salvage value associated with the machinery. The salvage value was calculated using the Iowa State University Extension and Outreach- Estimating Farm Machinery Cost article.

Based on calculations using the enterprise budget software, the ownership and operating costs of the conventional system is $213.29 per acre, with $87.69 per acre in operating costs and $125.60 per acre in ownership costs.

The total cost of the reduced-till system is $168.13, with the estimated operating cost at $64.57 per acre and the estimated ownership costs at $103.56 per acre.

When comparing the reduced-till system with the conventional till system, there is a savings of $45.16 per acre, or about 21 percent. Likewise, with reduced-till Farmer E is saving 130.5 hours of labor every year, or roughly 0.3 hours of labor savings for every acre of sugar beets.

Figure 16. Reduced-till beet field with residue, June 2014, Big Horn County.

Figure 17. Reduced-till beet field with residue, June 2014, Big Horn County.

Table 25. Farmer E Conventional operations

Crop	DATE	OPERATION
BEETS	YR 1 July 31	Bale straw
	YR 1 Aug. 2	Disk, tandem heavy
	YR 1 Aug. 2	Roller harrow
	YR 1 Aug. 2	Disk, tandem light
	YR 1 Aug. 2	Roller harrow
	YR 1 Aug. 15	Broadcast fertilizer
	YR 1 Aug. 16	Disk, tandem light
	YR 1 Aug. 16	Roller harrow
	YR 1 Aug. 30	Land plane
	YR 1 Aug. 30	Land plane
	YR 1 Sept. 1	Furrow shaper
	YR 1 Sept. 30	Spray herbicide
	YR 2 April 5	Plant beets, double-disk opener with starter fertilizer
	YR 2 May 15	Spray herbicide and fungicide
	YR 2 June 10	Spray herbicide
	YR 2 June 20	Start flood irrigation
	YR 2 Sept. 3	Stop flood irrigation
	YR 2 Oct. 4	Harvest beets
BARLEY	YR 2 Oct. 31	Disk, tandem heavy
	YR 2 Nov. 1	Broadcast fertilizer
	YR 2 Nov. 2	Disk, tandem light
	YR 2 Nov. 3	Roller harrow
	YR 2 Nov. 10	Land plane
	YR 2 Nov. 11	Land plane
	YR 2 Nov. 13	Furrow shaper
	YR 3 Mar. 1	Drill barley, double-disk opener
	YR 3 April 15	Spray herbicide and fungicide
	YR 3 May 1	Start flood irrigation
	YR 3 June 20	Stop flood irrigation
	YR 3 July 30	Harvest barley
BARLEY	YR 3 July 31	Bale straw
	YR 3 Aug. 2	Disk, tandem heavy
	YR 3 Oct. 20	Broadcast fertilizer
	YR 3 Nov. 1	Chisel plow
	YR 3 Nov. 1	Roller harrow
	YR 3 Nov. 15	Land plane
	YR 3 Nov 15	Furrow shaper
	YR 4 Mar. 1	Drill barley, double-disk opener with starter fertilizer
	YR 4 April 15	Spray herbicide and fungicide
	YR 4 May 1	Start flood irrigation
	YR 4 June 20	Stop flood irrigation
	YR 4 July 30	Harvest barley

Table 26. Farmer E Reduced-till operations

Crop	DATE	OPERATION
BEETS	YR 1 July 31	Bale straw
	YR 1 Aug. 5	Heavy harrow
	YR 1 Aug. 10	Broadcast fertilizer
	YR 1 Aug. 12	Heavy harrow
	YR 1 Oct. 15	Spray herbicide
	YR 2 April 3	Spray herbicide and insecticide
	YR 2 April 5	Plant beets, double-disk opener with starter fertilizer
	YR 2 May 15	Spray herbicide and fungicide
	YR 2 June 10	Spray herbicide
	YR 2 June 20	Start flood irrigation
	YR 2 Sept. 3	Stop flood irrigation
	YR 2 Oct. 4	Harvest beets
BARLEY	YR 2 Oct. 31	Disk, tandem heavy
	YR 2 Nov. 1	Broadcast fertilizer
	YR 2 Nov. 2	Cultivator
	YR 2 Nov. 3	Roller harrow
	YR 2 Nov. 11	Land plane
	YR 2 Nov. 13	Furrow shaper
	YR 3 Mar. 1	Drill barley, double-disk opener
	YR 3 April 15	Spray herbicide and fungicide
	YR 3 May 1	Start flood irrigation
	YR 3 June 20	Stop flood irrigation
	YR 3 July 30	Harvest barley
BARLEY	YR 3 July 31	Bale straw
	YR 3 Aug. 25	Heavy harrow
	YR 3 Nov. 1	Spray herbicide
	YR 4 Jan. 25	Broadcast fertilizer
	YR 4 Mar. 1	Drill barley, double-disk opener
	YR 4 April 15	Spray herbicide and fungicide
	YR 4 May 1	Start flood irrigation
	YR 4 June 20	Stop flood irrigation
	YR 4 July 30	Harvest barley

Conservation Factors

Soil type: Silty Clay
Soil Loss Tolerance: 5 tons/acre/year

Conventional Operations
Average annual soil loss: 7.6 tons/acre/year
STIR: 159
SCI: -0.6

Reduced-till Operations
Average annual soil loss: 2.2 tons/acre/year
STIR: 62
SCI: 0.3

Table 27. Farmer E partial budget analysis.

REDUCED TILLAGE	OPERATING	OWNERSHIP	TOTAL		ACRES	HOURS	HOURS/ ACRE	ACRES/ HOUR
Planter	8.94	27.39	36.33		380	25	0.07	15
Heavy Harrow	4.74	6.08	10.82		760	15	0.02	51
Baler	7.42	10.16	17.58		380	26	0.07	15
Roller Harrow	7.71	9.16	16.87		1140	56	0.05	20
Land Plane	4.64	5.65	10.29		760	38	0.05	20
Ridger	2.90	9.24	12.14		380	15	0.04	25
Sprayer	5.64	8.04	13.68		1520	38	0.03	40
Harvester	22.58	27.4	50.42		380	37	0.10	10
Total	**$64.57**	**$103.56**	**$168.13**			**250**		
CONVENTIONAL TILLAGE	**OPERATING**	**OWNERSHIP**	**TOTAL**		**ACRES**	**HOURS**	**HOURS/ ACRE**	**ACRES/ HOUR**
Planter	10.2	20.48	30.68		380	25	0.07	15
Defoliator	8.06	15.46	23.52		380	54.5	0.14	7
Digger	7.99	20.45	28.44		380	52	0.14	7
Tandem Disk	27.58	29.03	56.61		1140	76	0.07	15
Baler	8.18	8.58	16.76		380	26	0.07	15
Roller Harrow	8.48	8.39	16.87		1140	56	0.05	20
Land Plane	5.41	5.26	10.67		760	38	0.05	20
Ridger	6.15	9.91	16.06		380	15	0.04	25
Sprayer	5.64	8.04	13.68		1520	38	0.03	40
Total	**$87.69**	**$125.60**	**$213.29**			**380.5**		
SAVINGS	**OPERATING**	**OWNERSHIP**	**TOTAL**		**ACRES**	**HOURS**	**HOURS/ ACRE**	**ACRES/ HOUR**
Total	**$23.12**	**$22.04**	**$45.16**		**380**	**130.5**	**0.34**	
Percent savings			**21%**					

FARMER F – Carbon County

Table 28. Farmer F crop production.

CROP	ACRES IN 2016	YIELD
Sugar beets	243	35 ton/ac
Malt barley	300	120 bu/ac

Farmer F is located in Carbon County near the Clark Fork River and grows about 243 acres of sugar beets each year. His rotation is usually beets-barley-barley. The majority of his irrigation is a flood system, but he would like to change to pivot irrigation as soon as he can. Just like Farmer E, he also irrigates at night to avoid scalding his beets, as he has little slope in his fields. He usually needs six to seven irrigation sets on his beets during the growing season, and it takes 12 hours for one irrigation set to travel across a field. With reduced-till he has to push more water with more pressure to get adequate coverage. He has moved from two-inch tubes to four-inch tubes to get enough water on the field. Farmer F says irrigating his beets is more like irrigating his barley from a water volume and pressure perspective.

He does run a corrugator in his beets every 44 inches at three-inch depth around the first part of June, prior to his first irrigation. He finds that the water will move around blockages without washing anything away because of adequate residue on his fields.

Figure 18. Farmer F flood irrigation system, July 2016. Notice beet rows are diagonal to irrigation ditch.

Farmer F is experimenting with grazing cover crops after his barley harvest. He plants the cover crop in late August with a broadcast seeder and harrows after seeding. He will irrigate with one set of about two inches of water. In 2015 he grazed 75 acres of cover crop with 65 mother cows for two months in December and January. This also included an additional 35 acres of river bottom ground, plus 15 acres of alfalfa stubble. He would not do a cover crop without grazing, as he thinks too much residue would be left.

Farmer F allowed his malt barley to volunteer in 2015, which led to too much residue in the field and quite a bit of nitrogen tie-up. As a result, the beets that followed in that field did not do well in 2016. It must be noted that fields without this problem were thriving, and Farmer F plans to not repeat this mistake.

Figure 19 (left). Field with too much barley residue resulted in beet skips and nitrogen tie-up, July 2016.
Figure 20 (right). Thriving field of reduced-till beets, July 2016.

See Tables 29 and 30 below for sugar beet operation sequence. Everything except the fertilizer application was used in the analysis. The fertilizer application is custom hired. Farmer F owns all the machinery involved in the sugar beet operation. He is a good mechanic and is very thrifty with his equipment. He doesn't have new equipment and does a good job of repairing what he has.

Based on calculations using the enterprise budget software, the ownership and operating costs of the conventional system is $139.37 per acre, with $80.60 per acre in operating costs and $58.77 per acre in ownership costs.

The total cost of the reduced-till system is $91.67, with the estimated operating cost at $50.79 per acre and the estimated ownership costs at $40.88 per acre.

When comparing the reduced-till system with the conventional till system, there is a savings of $47.70 per acre, or about 34 percent. Likewise, with reduced-till Farmer F is saving 250 hours of labor every year, or roughly one hour of labor savings for every acre of sugar beets.

Table 29. Farmer F Conventional operations

	DATE	OPERATION
BEETS	YR 1 Aug. 28	Disk ripper
BEETS	YR 1 Sept. 3	Roller harrow
BEETS	YR 1 Sept. 10	Land plane
BEETS	YR 1 Sept. 12	Land plane
BEETS	YR 1 Sept. 15	Land plane
BEETS	YR 1 Sept. 30	Broadcast fertilizer
BEETS	YR 1 Oct. 1	Furrow shaper - corrugator
BEETS	YR 2 April 1	Ridge roller
BEETS	YR 2 April 1	Plant beets, double-disk opener
BEETS	YR 2 April 15	Spray herbicide
BEETS	YR 2 May 5	Spray herbicide
BEETS	YR 2 May 12	Cultivator, between rows
BEETS	YR 2 May 30	Spray herbicide
BEETS	YR 2 June 1	Spray fungicide
BEETS	YR 2 June 15	Start irrigation
BEETS	YR 2 Sept. 3	Stop irrigation
BEETS	YR 2 Oct. 3	Harvest beets
BARLEY	YR 3 Mar. 10	Broadcast fertilizer
BARLEY	YR 3 Mar. 11	Vibrashank cultivator
BARLEY	YR 3 Mar. 12	Corrugate, 44”
BARLEY	YR 3 Mar. 15	Drill barley
BARLEY	YR 3 May 5	Spray herbicide
BARLEY	YR 3 May 30	Start irrigation
BARLEY	YR 3 July 4	Stop irrigation
BARLEY	YR 3 July 20	Harvest barley
BARLEY	YR 3 Aug. 25	Spray herbicide
BARLEY	YR 3 Dec. 1	Graze
BARLEY	YR 4 Mar. 1	Broadcast fertilizer
BARLEY	YR 4 Mar. 2	Vibrashank cultivator
BARLEY	YR 4 Mar. 3	Vibrashank cultivator
BARLEY	YR 4 Mar. 15	Drill barley
BARLEY	YR 4 May 5	Spray herbicide
BARLEY	YR 4 May 30	Start irrigation
BARLEY	YR 4 July 4	Stop irrigation
BARLEY	YR 4 Aug. 1	Harvest barley

Table 30. Farmer F Reduced-till operations

	DATE	OPERATION
BEETS	YR 1 Aug. 28	Spray herbicide
BEETS	YR 1 Sept. 20	Broadcast fertilizer
BEETS	YR 2 April 1	Plant beets
BEETS	YR 2 April 15	Spray herbicide
BEETS	YR 2 May 5	Spray herbicide
BEETS	YR 2 May 30	Spray herbicide
BEETS	YR 2 June 1	Spray fungicide
BEETS	YR 2 June 5	Furrow shaper - corrugator
BEETS	YR 2 June 15	Start irrigation
BEETS	YR 2 Sept. 3	Stop irrigation
BEETS	YR 2 Oct. 3	Harvest beets
BARLEY	YR 2 Oct. 29	Light disk
BARLEY	YR 2 Nov. 4	Broadcast fertilizer
BARLEY	YR 3 Mar. 15	Drill barley
BARLEY	YR 3 May 5	Spray herbicide
BARLEY	YR 3 May 30	Start irrigation
BARLEY	YR 3 July 4	Stop irrigation
BARLEY	YR 3 July 20	Harvest barley
BARLEY	YR 3 Aug. 5	Spray herbicide
BARLEY	YR 3 Aug. 25	Broadcast cover crop
BARLEY	YR 3 Aug. 27	Irrigate once
BARLEY	YR 3 Dec. 1	Graze
BARLEY	YR 4 Mar. 4	Broadcast fertilizer
BARLEY	YR 4 Mar. 15	Drill barley
BARLEY	YR 4 May 5	Spray herbicide
BARLEY	YR 4 May 30	Start irrigation
BARLEY	YR 4 July 4	Stop irrigation
BARLEY	YR 4 Aug. 1	Harvest barley

Conservation Factors

Soil type: Silty clay loam
Soil loss tolerance: 5 tons/acre/year

Conventional Operations
Average annual wind erosion: 7.1 tons/acre/year
STIR: 77
SCI: 0.1

Reduced-till operations
Average annual wind erosion: 1.1 tons/acre/year
STIR: 24
SCI: 0.9

Table 27. Farmer F partial budget analysis.

REDUCED TILLAGE	OPERATING	OWNERSHIP	TOTAL		ACRES	HOURS	HOURS/ ACRE	ACRES/ HOUR
Sprayer	12.25	13.05	25.30		1215	49	0.04	25
Ridger	2.20	2.37	4.57		243	24	0.10	10
Planter	9.93	9.12	19.05		243	60	0.25	4
Defoliator	11.78	8.21	19.99		243	164	0.67	1
Digger	14.63	8.13	22.76		243	159	0.65	2
Total	**$50.79**	**$40.88**	**$91.67**			**456**		
CONVENTIONAL TILLAGE	**OPERATING**	**OWNERSHIP**	**TOTAL**		**ACRES**	**HOURS**	**HOURS/ ACRE**	**ACRES/ HOUR**
Disk Ripper	13.03	7.63	20.66		243	60.5	0.25	4
Roller Harrow	7.57	3.48	11.05		243	54	0.22	5
Sprayer	11.56	11.31	22.87		972	39	0.04	25
Corrugator	5.15	3.45	8.60		486	48.5	0.10	10
Planter	7.46	7.34	14.80		243	60	0.25	4
Defoliator	9.30	6.43	15.73		243	164	0.67	1
Digger	14.09	8.18	22.27		243	159	0.65	2
De-Ridger	7.34	6.95	14.29		243	54.5	0.22	4
Land Plane	5.10	4.00	9.10		729	66.5	0.09	11
Total	**$80.60**	**$58.77**	**$139.37**			**706**		
SAVINGS	**OPERATING**	**OWNERSHIP**	**TOTAL**		**ACRES**	**HOURS**	**HOURS/ ACRE**	**ACRES/ HOUR**
Total	**$29.81**	**$17.89**	**$47.70**		**243**	**250**	**1.03**	
Percent savings			**34%**					

Conclusions

All landowners in this report had an estimated savings of 21 percent to 57 percent in ownership and operating costs when they converted to a reduced tillage system for sugar beet production savings. There was a considerable reduction in operating costs more than ownership costs, in part because of decline in machinery usage. Most of the landowners reduced their machinery usage by several operations. This translates into tremendous fuel, maintenance, and labor reductions.

Table 32. Summary cost and hourly savings for all farmers.

FARMER	CONVENTIONAL COST PER ACRE	REDUCED-TILL OR STRIP-TILL COST PER ACRE	DOLLAR SAVINGS PER ACRE	PERCENT SAVINGS	HOURLY SAVINGS PER ACRE
A	$206.30	$109.90	$96.40	47%	1.0
B	$162.24	$82.33	$79.97	49%	1.8
C	$243.22	$92.60	$150.62	62%	1.4
D	$226.70	$161.18	$65.52	29%	0.8
E	$213.29	$168.13	$45.16	21%	0.3
F	$139.37	$91.67	$47.70	34%	1.0

One of the striking differences among the subjects in this study is the variability of savings. One of the variables that create such a difference among the landowners is the machinery used. Even though the operational sequences are similar under conventional and reduced tillage for the landowners, the machinery used by each landowner is different. In which case, the performance rate for each machine is different. Again, performance rate relates to how many acres per hour a landowner can complete with that machinery.

Another variable is the different soil types among the landowners. Some farmers had an easier time implementing reduced-tillage on lighter soils with gentle slopes than others on heavier soils with little slope. In all cases, each farmer had to adjust the reduced-tillage system to their individual situation and could not adopt a “one size fits all” approach.

Because each reduced-till beet system is unique, farmers will need to continue sharing information in order to advance these systems, both in acreage and in conservation practice.

Finally, thank you to the growers who participated in this project, and the local NRCS staff who made these interviews possible. It is our hope that continued collaboration and sharing of information will lead to improved soil conservation in sugar beet systems in Montana and neighboring states.

For More Information

Contact your local NRCS field office for more information about conservation practices for your operation. Contact information can be found at www.mt.nrcs.usda.gov.

Contact Susan Tallman, Bozeman Area Agronomist, for more information about this report. Call 406-587-6856 or email susan.tallman@mt.usda.gov.

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Notes

Residue in Farmer D's reduced-till beet field.

Residue in Farmer D's reduced-till beet field after harvest.

Notes


Farmer E's reduced-till beet field, July 2014.


Soil in Farmer C's reduced-till beet field. Many earthworms were observed, although not noticeable in this photo.

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