BENEFITS OF STRIP TILLAGE TO INCREASE FARMING EFFICIENCY AND PROTECT WATER QUALITY

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Introduction

Strip tillage is a form of conservation tillage in which only the row zones are tilled. Strip tillage has the potential to increase the daily maximum soil temperature in the tilled rows compared to no till and enhance early seedling emergence, while using inter-row residue cover to conserve soil moisture. Strip tillage offers possible economic and environmental advantages to growers who convert from conventional tillage while simultaneously reducing soil erosion and improving water quality. Some of these advantages include: increased profit by eliminating several tillage operations; reduced labor, fertilizer, and fuel costs; equal or greater crop yields; reduced nutrient loss to runoff and leaching; reduced soil erosion and soil compaction; and increased water savings.

The purpose of this study was to determine if strip tillage in Malheur County would yield the same economic and environmental advantages that have been seen in other parts of the country. At least 1,388 acres of sprinkler-irrigated land in Malheur County were converted to strip tillage. Four study sites were used in 2011 to compare the economic yield, soil tillage intensity ratings (STIR), soil conditioning index (SCI) ratings, weed control program, and fuel usage of conventional and strip-tillage methods.

Methods

Four comparison sites were located in northern Malheur County, between the cities of Vale and Jamieson. Each site was partially tilled using conventional tillage methods while the greater part of the field was strip tilled. Three of the paired sites were planted to corn, while one of the paired sites was being used to grow dry beans. All four sites were irrigated using center pivot sprinkler systems.

Twenty sub-samples were taken in both the strip tilled and conventional tilled portion of the four sites in order to determine soil texture and soil nutrients. The samples from each site were taken to Western Laboratories (Parma, ID) to be analyzed. The standard procedure described by the USDA Natural Resources Conservation Service for the line-transect method was used to conduct soil residue cover measurements at the four sites used in this study (Agronomy Tech Note No. MN-19).

In order to measure soil moisture, Watermark Monitor dataloggers (Irrometer Co. Inc., Riverside, CA) were programmed to read Watermark Soil Moisture Sensors (Irrometer Co. Inc.) that were installed 8 and 20 inches deep at the four different sites. Soil temperature sensors were installed in the inter-row zone in the field planted to dry beans to measure any variability between the two tillage methods at shallow 4-inch depth. Soil moisture and temperature data were recorded hourly by the dataloggers. Data were collected approximately once a month between June 17 and September 5.

The Revised Universal Soil Loss Equation, version 2 (RUSLE2) was used to calculate soil loss, STIR values, SCI ratings, and fuel usage. Operational information gathered from grower interviews, climate, soil type, and slope were used as inputs to RUSLE2. Computations were performed using standard procedures outlined in the RUSLE2 Instructions & User Guide (USDA-NRCS 2004).

Experimental Results

The soil textural analyses indicated that all four sites had similar texture. Three of the sites were classified as sandy clay loams and the dry bean field was a sandy loam. The percentage of soil residue cover at each site and each tillage method were variable but the strip-tilled land residue cover was higher than the conventionally tilled residue cover at all four sites (Fig. 1).

All conclusions drawn from soil moisture data assume that the location of the sensors was representative of the entire field. The four sites were consistently over-irrigated throughout the monitoring period; both the shallow and deep sensors in the strip and conventional tillage were too wet (Fig. 2). Corn and beans should be irrigated when the soil water tension (SWT) reaches 50 to 60 cb at 8-inch depth (Shock and Wang 2011). No relationship was confirmed between tillage practice and SWT in either the shallow or the deep sensors. We hypothesized that the strip-tilled sites would retain more moisture; however, the data do not consistently support this relationship. The SWT was unpredictable and variable in the strip and conventional tillage and neither method was consistently wetter or dryer than the other.

At site 2, the soil temperature sensors revealed that the conventionally tilled soil in the dry bean field consistently reached higher maximum daily temperatures than those of the strip-tilled portion of the field between June and September (Fig. 3). All things being equal, cooler summer soil temperatures can be advantageous for shallow rooted beans, whose roots do not reach deeper soil moisture.

The crop yields from the studies in 2010 (Norberg 2011) and 2011 are listed in Table 1. While neither strip tillage nor conventional tillage consistently had higher crop yields, it is important to note that the yields were comparable for the two tillage methods.

Computational Results

The soil loss at each site varied between less than 1 ton/year/acre to 11 tons/year/acre (Table 2). The conventional tillage produced a higher STIR value than the strip tillage at all four study sites, indicating a higher level of soil disturbance in the conventional tillage (Fig. 4). The SCI values were positive at all the study sites except for site 2 (Fig. 5). The strip-tillage SCI ratings were higher than the conventional tillage SCI ratings at every site, indicating a higher potential for organic matter formation under strip tillage. Using strip tillage instead of conventional tillage consistently reduced fuel usage at all four study sites (Fig. 6). However, the fuel use of the strip-tillage operations was sometimes higher at one site than the conventional tillage operations at another due to different conditions in the fields and different operations utilized by individual growers.

In order to see how strip tillage really compared to traditional conventional tillage, a traditional conventional tillage sequence of operations was created for site 1 and analyzed in RUSLE2 (Table 3). Soil loss, STIR, fuel use, fuel cost, and energy use were all much higher in the traditional conventional operation sequence than in the conventional and strip-tillage operations used today. In addition, the SCI ratings were much lower in the traditional sequence than either the conventional or strip-tillage sequences used today. These results indicate that while the advantages gained from strip tillage may seem marginal, when compared to traditional conventional tillage they are much greater. Traditional conventional tillage practices are still practiced by many growers. Strip tillage is yet another best management practice that can be utilized in Malheur County to further reduce agriculture's environmental impact.

Discussion

The results of this study indicate that strip tillage in Malheur County is a viable way to reduce the environmental impact of conventional tillage while maintaining, or even increasing, yields. However, it should be noted that strip tillage is a relative term that is interpreted differently by each grower. Strip tillage will not produce uniform decreases in soil erosion across fields. The benefits of strip tillage depend on the grower resources, irrigation water management practices, and a number of site-specific variables. Strip tillage, or any reduced tillage operation, when combined with proper irrigation management practices, can reduce the environmental impact of tillage operations while maintaining economic viability. We suggest that while the environmental benefits of strip tillage are variable, it is certainly a best management practice option that, when used in conjunction with irrigation and nutrient best management practices, will help Malheur County growers move toward more sustainable agriculture.

References

Norberg, O.S. 2011. Strip tillage in Malheur and Owyhee Watersheds, annual report – June 30, 2011. Report to ODEQ.

Shock, C.C. and F.-X. Wang. 2011. Soil water tension, a powerful measurement for productivity and stewardship. HortScience 46:178-185.

USDA-NRCS. 2004. RUSLE2 Instructions & User Guide. United States Department of Agriculture, National Resources Conservation Service. 27 p.

Table 1. Crop yields for the conventional and strip-tilled portions of the study sites during 2010* and 2011. The yields are comparable between the conventional and strip tilled portion of each field, with neither tillage method consistently producing higher yields. Malheur Experiment Station, Oregon State University, Ontario, OR, 2011.

Year	Crop	Conventional tillage yield	Strip tillage yield
2010	Corn silage	32 ton/acre	30 ton/acre
2010	Dry edible beans	2,253 lb/acre	2,418 lb/acre
2011	Dry edible beans	4,180 lb/acre	4,688 lb/acre
	Bean avg.	**3,217 lb/acre**	**3,553 lb/acre**
2010	Corn for grain	239 bu/acre	248 bu/acre
2011	Corn for grain	254 bu/acre	242 bu/acre
2011	Corn for grain	215 bu/acre	201 bu/acre
2011	Corn for grain	160 bu/acre	171 bu/acre
	Corn avg.	**217 bu/acre**	**216 bu/acre**

*Yield results from 2010 are from Norberg (2011).

Table 2.The estimated soil loss at the four study sites was reduced under strip tillage. The percent savings ranged from 15-52 percent by using strip tillage. Estimated soil losses ranged from <1 ton/acre/year to 11 tons/acre/year at the study sites. Malheur Experiment Station, Oregon State University, Ontario, OR, 2011.

Site	Tillage method		Savings through	Percent
No.	Conventional	Strip	strip tillage	savings
	--------------- Soil loss (ton/acre/yr) ---------------			%
1	0.031	0.026	0.005	16
2	11.0	9.30	1.70	15
3	1.40	0.670	0.730	52
4	1.10	0.910	0.190	17

Table 3. The computational results of a traditional conventional tillage operations sequence compared to today's "conventional" and strip-tillage operations. Malheur Experiment Station, Oregon State University, Ontario, OR, 2011.

Tillage method	Irrigation method	Soil loss (tons/acre/yr)	STIR* (lower better)	SCI (higher better)	Fuel use (gal/acre)	Fuel cost ($/acre)	Energy use (BTU/acre)
Traditional conventional	Furrow	1.1	154	1.0	51	154.20	7,100,000
Traditional conventional	Sprinkler	1.1	151	1.1	49	147.30	6,800,000
Today's "conventional"	Sprinkler	0.031	85.5	1.9	20	59.30	2,700,000
Today's strip tillage	Sprinkler	0.026	61.8	2.0	17	52.47	2,400,000

*STIR = soil tillage intensity rating; SCI = soil conditioning index.

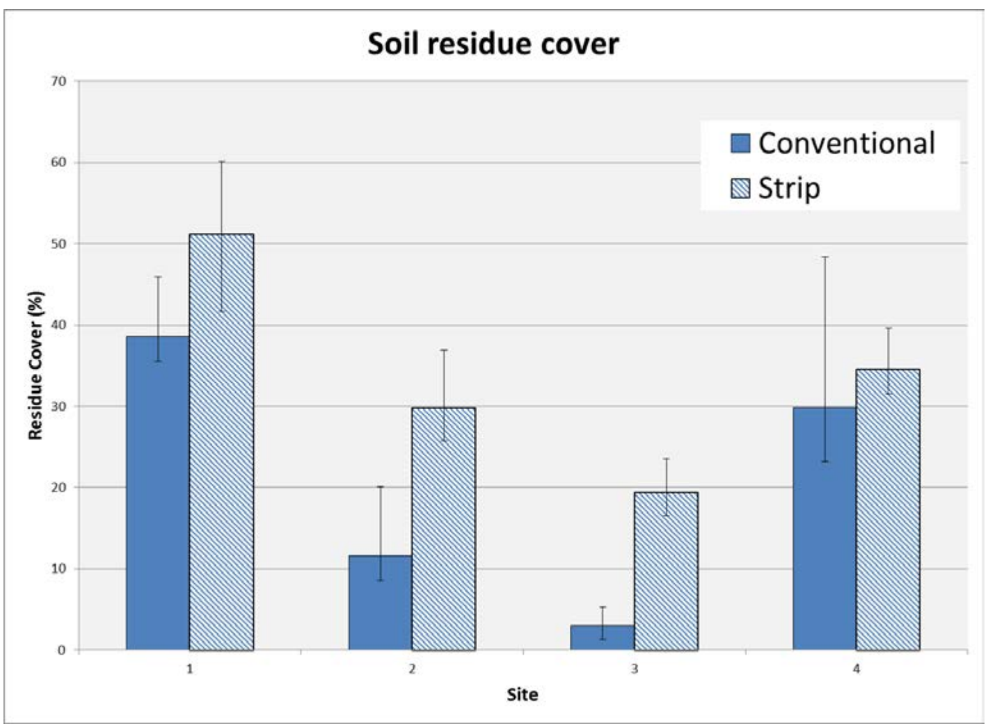


Figure 1. The mean percentage of soil residue cover of five measurements taken at each of the four sites in both conventional and strip-tilled land. The error bars associated with each percentage represent the upper and lower tolerance limits at the 95% confidence level.

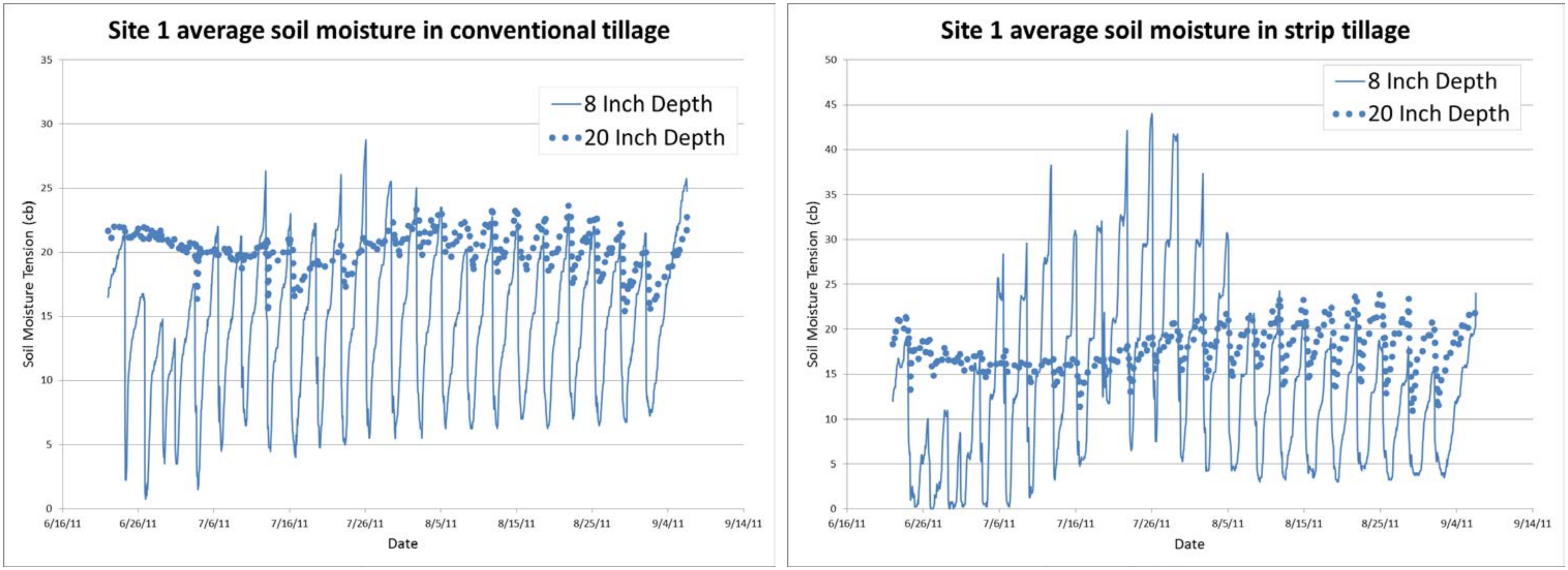
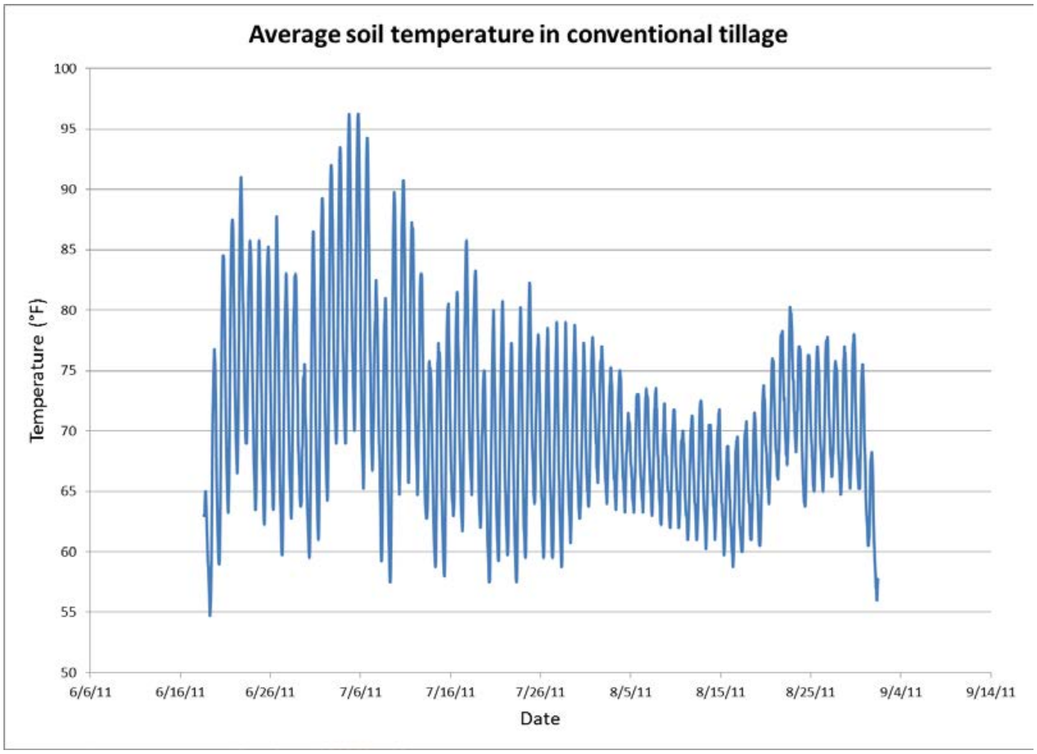


Figure 2.Soil moisture results from a corn field used in the strip-tillage study. The ideal soil moisture criteria for corn in Malheur County is between 50 and 60 cb (Shock and Wang 2011). Both the conventional tilled (left) and strip-tilled (right) portion of this site, as well as the soil at the other three sites, were consistently over-irrigated from June to September, 2011. Therefore, no relationship could be drawn at any depth between tillage method and soil moisture.



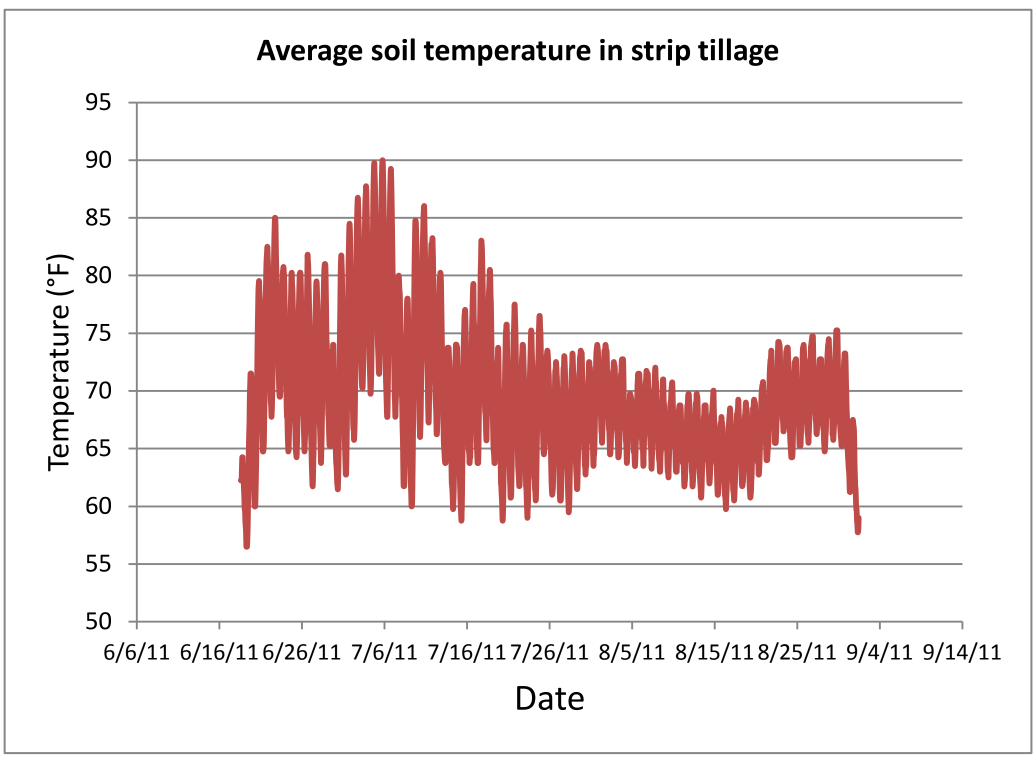


Figure 3. Soil temperature at 10-cm depth between plant rows in a field of dry edible beans. The conventionally tilled portion of the field consistently reached higher temperatures than the strip-tilled portion of the field during June to September 2011.

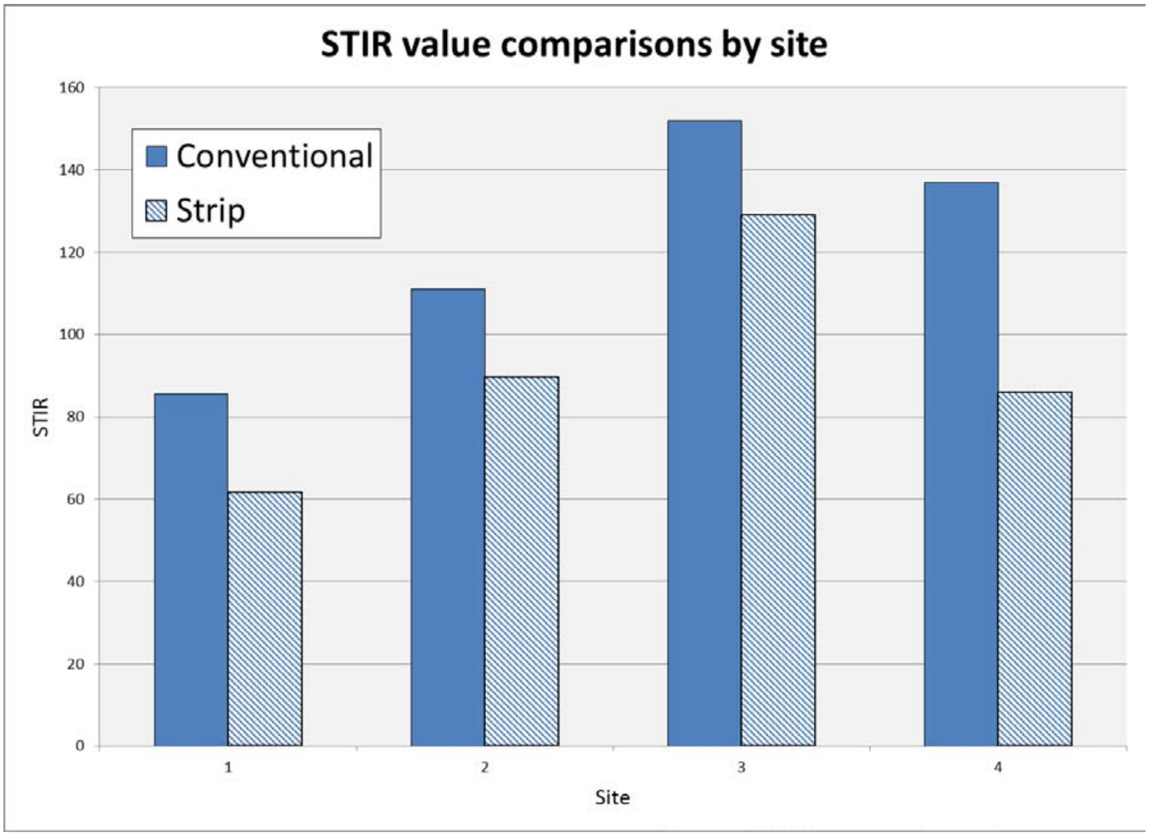


Figure 4. The STIR (soil tillage intensity rating) values of each tillage method at the four sites used in the strip-till trial. The conventional tillage produced a higher STIR value than the strip tillage at all four study sites, indicating a higher level of soil disturbance in the conventional tillage.

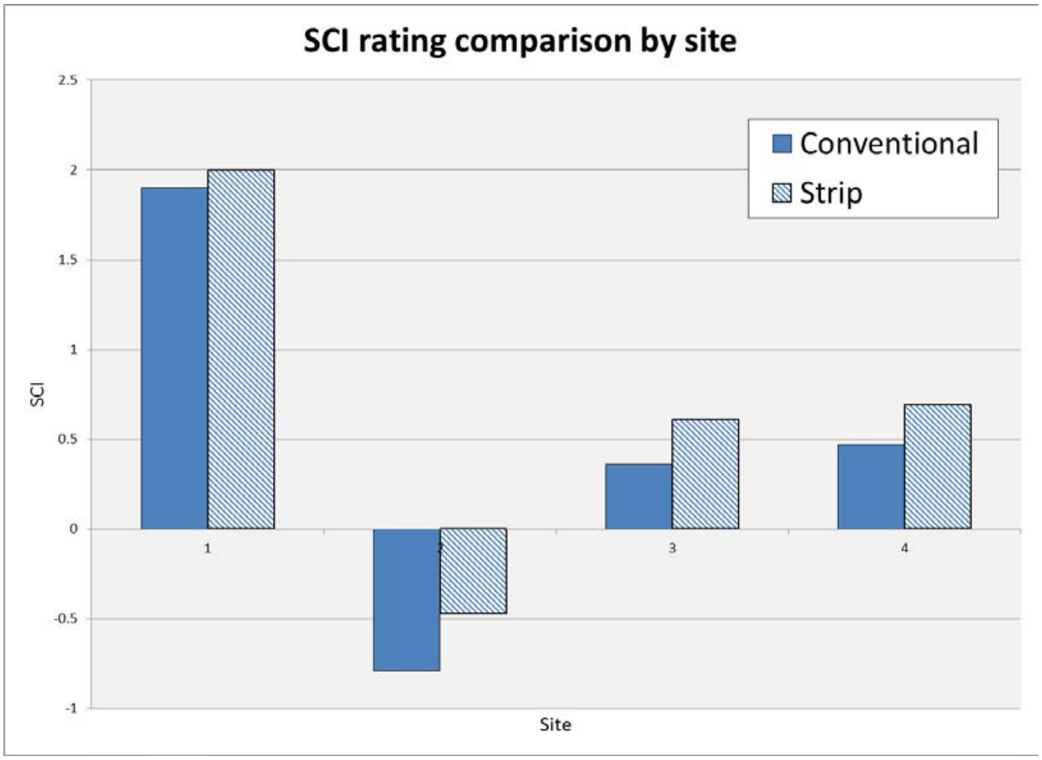


Figure 5.A comparison of the conventional tillage SCI (soil conditioning index) ratings to the strip-tillage SCI ratings at four sites. The SCI rating of the strip tillage is higher than that of the conventional tillage at all four sites, indicating a greater potential for organic matter in the strip tillage.

Figure 6. The fuel cost associated with conventional tillage and strip tillage at each site. The strip tillage required less fuel than the conventional tillage at all four sites. However, the fuel costs across sites were variable.