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Strip-tillage: A conservation option for Wisconsin farmers

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Wisconsin growers have a renewed interest in conservation tillage systems, driven by rising fuel and equipment costs, the desire to plant crops in a timely manner, and concerns about soil conservation because of catastrophic erosion events. Recent increases in crop acres managed by individual producers also favor practices that allow growers to cover more acres in less time than would be possible with conventional tillage. Ideally a conservation tillage system permits farmers to conserve soil without a reduction in profitability.

The easiest approach to conservation tillage is not tilling at all and simply planting into the crop residue on the field. Historically, no-tillage management has been a challenge for corn production in Wisconsin because the crop residue left on an untilled field slows soil warming in the spring, leading to delayed germination and growth. Residue can also physically impair planting by causing plugging within the planting unit and "hair-pinning" residue in the seed slot. Therefore, most of those who have employed no-tillage management have used corn planters modified to include some type of in-row residue management attachment, either as finger coulters or disks that are designed to move some residue from the row without substantial contact with the soil. Still, the problems associated with residue and delayed soil-warming mean that only 10–15% of the corn crop and 30–40% of the soybean crop is no-till planted in Wisconsin every year.

Many producers are now considering more aggressive attachments or separate tillage operations that not only address residue concerns but also till the soil to some degree. The purpose of these attachments is to capture the production advantages of full-width tillage while offering the soil conservation benefits of no-tillage. This practice has come to be known as **strip-tillage.**

What is strip-tillage?

Strip-tillage can be defined as less than full-width tillage of varying intensity that is conducted parallel to the row direction. Generally no more than 30% of the soil surface is disturbed by this practice, leaving most of the previous crop's residue intact. Strip-tillage is commonly accomplished with a single pass with a separate implement in the fall to create a strip of soil that will warm quickly in the spring.

The goal of strip-tillage is to create a seedbed condition in the row that is similar to that achieved by full-width tillage systems, such as chisel plowing, without disturbing the remaining soil. This leaves a relatively large amount of crop residue on the inter-row soil surface to absorb raindrop energy and provide a barrier to runoff. It also enhances infiltration by maintaining open worm channels and other macropores at the surface. These factors combine to reduce runoff and soil erosion. Strip-tillage is also accomplished in a shorter time and with fewer energy inputs than full-width tillage.

Strip-tillage is also possible in the spring on some soils if moisture and residue conditions permit. Some planters are equipped with attachments that conduct tillage in the row just ahead of the planting units, while some producers have adopted the practice of conducting shallow strip-tillage often a few hours prior to planting.

The type of strip-tillage tool used is determined by the stoniness of the soil, the amount and condition of the residue, the potential for soil compaction, power requirements, and other factors specific to individual producers. Growers seeking information that would help them select the type of strip-tillage tool for their cropping system and soils should consult with their county Extension agent. Progressive equipment dealers, crop advisors, and other growers are also knowledgeable about issues related to tool selection. Table 1 describes the categories of strip-tillage related to tillage depth or intensity and the attachment types and functions of each. Figure 1 shows examples of the three types of strip-tillage tools.

Strip-tillage is more commonly conducted following soybean, fall-killed legume forage, or other fragile residue crops because of the concern of plugging within the tillage tool and the ability to create a residue-free strip after a corn crop. Newer, more aggressive strip-tillage tools have been built to handle corn residue in response to the desire of farmers to grow more continuous corn. Some producers also apply fertilizer with their strip-tillage tool, thereby eliminating one trip over the field and the need for planter-applied fertilizer. See the sidebar **Applying fertilizer in strip-tillage** for more information.

Strip-tillage, if coordinated with other field operations, can be considered a method of "controlled traffic farming." This practice, which is much more common in Europe and Australia, confines wheel traffic to specific lanes to limit soil compaction. To practice controlled traffic farming in standard row crop production, farmers would need to standardize the traffic caused by various field operations to limit the amount of field area that is driven over. This is especially true of heavy equipment such as combines, manure tankers, and large fertilizer spreaders. This may require that some strip-tillage practitioners invest in very accurate GPS and tractor auto-steer systems to ensure that planted rows are placed on the previously strip-tilled ground.

Table 1. Summary of strip-tillage tool types

Strip-tillage category	Attachment types	Function
Residue clearing	Finger or notched coulters, sweeps, brushes	Move residue from the row area. Typically mounted on most no-tillage planters.
Shallow strip-tillage 2–3 inches	Fluted and notched coulters	Cut and move residue, loosen seedbed, apply fertilizer near the seed. Typically mounted on the planter, but can be operated on a separate tool bar. Favored on stony soils.
Moderate strip-tillage 8–10 inches	Cutting coulters, mole knives, ridging coulters	Cut and move residue, remove surface compaction, create seedbed, deep-place fertilizer, form a small ridge that will dry and warm quickly.
Deep strip-tillage > 10 inches	Straight-shanked knife with limited soil inversion	Remove subsoil compaction.

Figure 1. Examples of strip-tillage tool categories (left to right): row-clearing coulter, shallow strip-tillage tool, moderate strip-tillage tool

Applying fertilizer in strip-tillage

One of the advantages of fall strip-tillage is that it allows the grower to apply fertilizer at the same time. Phosphorus (P) and potassium (K) materials are appropriate to add in the fall, but the application of anhydrous ammonia or other nitrogen (N) fertilizers is discouraged because of lower N use efficiency and potential for loss by leaching.

Another matter is how the fertilizer is applied. A four-year study examined the placement of P and K fertilizer to determine whether there was a benefit to banding the material deeper compared to standard methods in both continuous corn (CC) and corn/soybean (C/S) rotation crops. The four methods used were no fertilizer treatment at all and 200 pounds per acre of 9-23-30 fertilizer applied as a fall broadcast, a fall strip using the mole knife to place it at a depth of about 6 to 7 inches, and a planter-applied treatment in a 2 x 2 placement. The average yield responses for the different placement treatments in the CC and C/S rotations are shown in table 2. These results show that while there was minimal difference between placement methods, C/S was much more responsive to fertilization than CC.

Additionally, because soil test P was in the excessively high range for this soil and soil test K was in the optimum range, any response to the fertilizer would have been expected to be from the applied K.

Growth and yield response to strip-tillage

Grain farmers in the northern Corn Belt have been frustrated with the slower growth and reduced yields often associated with the cooler spring soil conditions of no-tillage planting. Strip-tillage, in contrast, has been shown to promote warming within the seed zone because it allows more of the energy of the sun to reach the soil surface. Figure 2 shows the soil temperatures measured at two inches below the soil surface over several weeks in Arlington, WI. Soil temperatures in the fall strip-till treatment were similar to those where soil had been chiseled and up to 10°F warmer than no-tillage. Emergence and early growth in this study were delayed in the no-tillage case compared to the chisel and fall strip-tillage systems at least until silking, as shown in table 3.

Table 2. Corn grain yield as affected by fertilizer placement in strip-tillage, 2001–2004; Arlington, WI

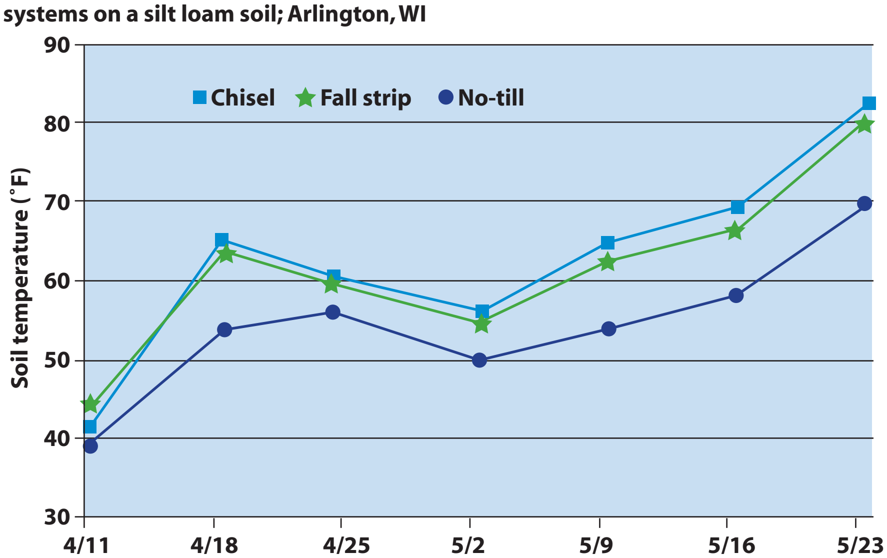
Placement*	CC (bu/a)	C/S (bu/a)
None	169	184
Broadcast	166	208
2 x 2	170	200
Deep	163	202

*200 pounds per acre of 9-23-30 fertilizer

Table 3. Emergence, early growth, and silking progress in corn crops as affected by tillage; Arlington, WI

Tillage system	Emergence plants/foot	V6 (6-leaf) grams/plant	V12 (12-leaf) grams/plant	Silking %
Chisel	1.8	1.1	29	80
Strip-tillage	1.6	1.1	28	62
No-tillage	0.7	0.7	18	36

Figure 2. Soil temperature measured in continuous corn under three tillage systems on a silt loam soil; Arlington, WI



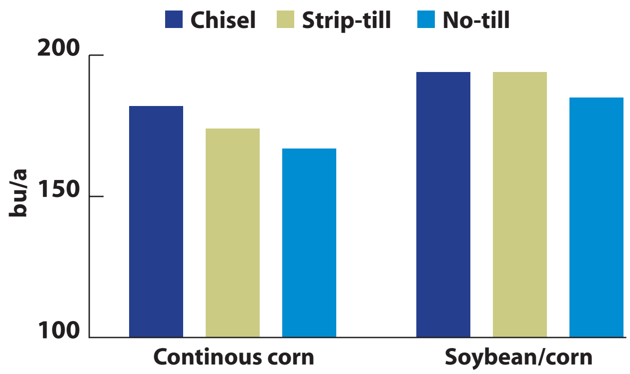
A long-term research study conducted at the University of Wisconsin-Madison Arlington Agricultural Research Station compared fall strip-tillage with fall chisel/spring field cultivator and no-tillage systems in both continuous corn (CC) and a soybean corn (S/C) rotation. The strip-tillage tool in this study featured a mole knife that was run about 8 inches deep and built a 2- to 3-inch ridge upon which the subsequent crop was planted. The no-tillage system (without row cleaners) used in these trials represented the extreme minimum tillage practice. Both the strip-tillage and no-tillage rows were alternated 15 inches between years.

The effect of tillage on corn grain yield is shown in figure 3. These data showed equal corn grain yield in first-year corn when comparing chisel and strip-tillage averaged over 10 seasons. No-tillage yields were about 5% lower. Yields in CC over the same time period were highest in the chisel system and found to be about 4% greater than strip-tillage and 8% greater than no-tillage.

Soil conservation and strip-tillage

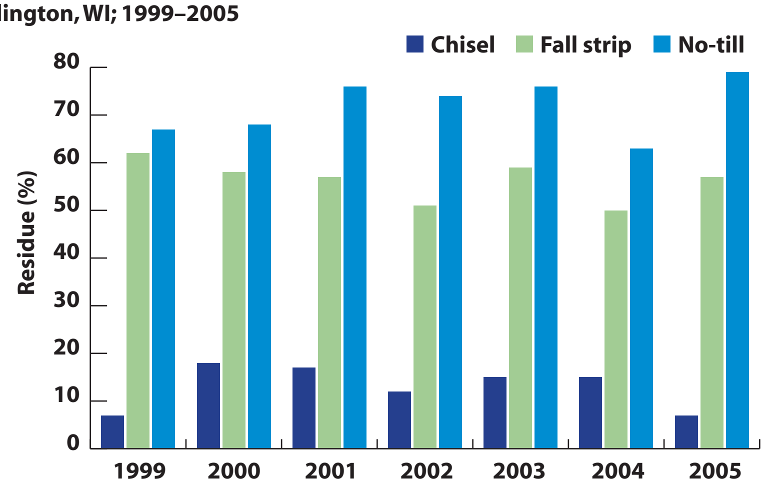
Strip-tillage systems disturb only a portion of the soil surface; therefore, most of the previous crop residue remains. The crop residue absorbs the impact energy of raindrops and limits aggregate dispersal and crusting, impeding overland flow and providing more time for runoff to infiltrate through soil pores. Figure 4 shows the crop residue measured after planting in the S/C rotation of the Arlington study from 1999–2005. These data show that chisel tillage of the fragile soybean residue reduced crop residue to an average of about 15%, whereas strip-tillage and no-tillage both favored crop residue coverage, resulting in 55–70% cover range. The amount of crop residue left after strip-tillage was about 15–25% less than that of no-tillage but substantially more than that left if a full-width tillage system, such as chisel plowing, was used.

Figure 3. **Average corn yield response to tillage in continuous corn and in a soybean/corn rotation, Arlington, WI; 1997–2007**



Note: Yield was not recorded in 2000

Figure 4. **Surface crop residue measured in first-year corn after soybean, Arlington, WI; 1999–2005**



The direct benefit of strip-tillage on soil conservation was demonstrated in a research study conducted at the Lancaster Agricultural Research Station. Passive runoff collectors were installed in a field with both chisel and strip-tillage on an 8% slope. These collectors trapped sediment eroded from a 100-square-foot area uphill from their placement. The measured soil loss in a year that experienced substantial rainfall during the early part of the growing season prior to crop canopy closure was 4.67 tons soil/acre in chisel but only 0.28 tons soil/acre in strip-tillage.

The economic advantage of strip-tillage

In addition to yield and environmental performance differences across tillage systems, the economic cost of production (COP) must be considered when selecting a tillage system. Reduced tillage systems commonly generate fewer trips across the fields, using the same or less horsepower to accomplish more tasks (e.g., tillage and fertilization in one pass). Hence, reduced tillage systems should reduce the costs of production as they increase environmental performance via decreased soil and nutrient losses.

Measuring these potential reduced costs on a \$/bushel (versus \$/acre) basis provides an adjustment for the possibility of lower yields under the reduced tillage systems (see figure 3 and table 4). Using recent cost values, the 10 years of yield data collected in the Arlington Tillage Rotation Study were used to compare the economic performance of reduced tillage systems with that of chisel plowing.

For the CC portion of these field trial 1997–2007 average yields, ST and NT respectively averaged 8 and 15 bu/acre less than CH (182 bu/acre). However, the estimated COP/acre was lower than CH for both reduced tillage systems: ST was –\$23.20/acre and NT was –\$25.90/acre. Comparison of these tillage systems on a per-bushel basis adjusts for the yield as well as cost differences. When accounting for the reduced yield in these tillage systems, the reduced costs/bushel are overshadowed, resulting in either a small benefit or loss (\$0.02/bu benefit for ST or an \$0.08/bu loss for NT).

The situation changes in the S/C rotation. In contrast to the CC results, the first-year S/C under ST yields are virtually identical to CH, while yield under NT is reduced 9 bu/acre compared to CH.

Given that COP are similar to CC, these more competitive yield differences generate favorable returns to reduced tillage: for ST the COP is –\$0.12/bu compared with CH while NT is –\$0.03/bu. This suggests that both cost savings and improved environmental performance are possible with these reduced tillage S/C systems compared to CH, with ST providing stronger economic gains compared to NT.

The soybean (C/S) rotation results favor conservation tillage even more. On a per-bushel basis, these yield and COP differences translate to –\$0.18/bu (ST) and –\$0.26/bu (NT) cost savings over CH.

Table 4. Comparison of 2007 cost of production (COP) for strip-till and no-tillage to chisel plow 1997–2007; Arlington, WI

Crop/ System	1997–2007 Average yield	2007 COP/acre (\$/acre)	2007 COP/bushel (\$/bushel)
Continous corn			
CH	182	—	—
ST	174	–23.20	–0.02
NT	167	–25.90	0.08
Corn after soybean			
CH	194	—	—
ST	194	–23.20	–0.12
NT	185	–25.90	–0.03
Soybean after corn			
CH	52	—	—
ST	52	–11.20	–0.18
NT	50	–25.90	–0.26

CH = fall chisel/spring cultivator, assumed as the reference tillage; ST = fall strip-tillage; NT = no-tillage without residue managers

Current grain prices, production costs, and 2007 Wisconsin custom hire rates were used in the calculations.

Selecting a strip-tillage system

Before changing tillage systems, evaluate your current system. Often modification of existing equipment or management, such as adding residue-clearing coulters to a row-crop planter, may be all that is required. Ask yourself some simple questions:

- Am I meeting my conservation goals?
- Is spring tillage limiting planting timeliness?
- Is the residue left by no-tilling reducing stands and/or slowing emergence?
- Is compaction an issue?
- Are my yields reasonable for my soil type and location?

If the answer to any of these brings concern, then some adjustment in tillage management may be warranted.

The selection of a strip-tillage system is dependent on a grower's soil, cropping system, and management capabilities. For example, if your fields are stony, then consider a strip-tillage tool that features coulters rather than one that has knives. Soils with relatively high clay content may offer greater response to systems that provide shallow in-row tillage with a mole knife to break up surface compaction and move residue while forming a small ridge to promote drying in the row. This will improve seed-to-soil contact and permit planting into more favorable conditions. If deep compaction is a concern, then there may be a need to consider deep strip-tillage. It is critical to identify compaction if it exists and to locate the depth of the restrictive layer. Tools for this operation should provide minimal soil inversion because it would disturb a large portion of the soil volume and bury residue.

The bottom line

Evaluating the economics of tillage systems is very complex. Consideration must be given to the initial and maintenance costs of equipment, the size of tractor needed to pull the tool, equipment depreciation, labor and opportunity costs, conservation program incentives, and variable management costs related to fertilizer and pest management.

Producers have to determine if it is cost-effective to strip-till all row crops, as opposed to only strip-tilling first-year corn into soybean stubble or fall-killed alfalfa, no-till planting soybean into corn or small grain stubble, and using chisel plowing or similar full-width systems for growing continuous corn.

In order to make such determinations, growers are encouraged to set up simple side-by-side comparisons of different tillage systems to evaluate the results in their soil conditions.

When properly adapted to local conditions, strip-tillage has been shown to be a tillage option that conserves soil, reduces production costs, saves time, and produces yields that are higher than no-tillage and nearly equivalent to those produced by full-width systems.

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