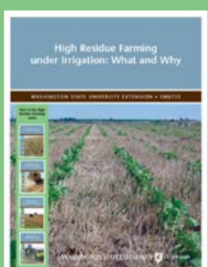
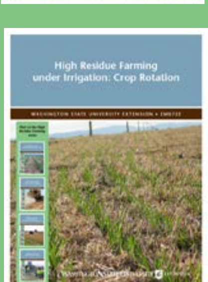
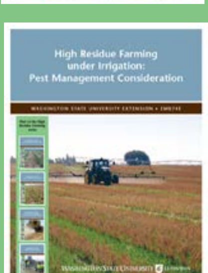
High Residue Farming Under Irrigation: Strip-till

WASHINGTON STATE UNIVERSITY EXTENSION • EM036E

Part of the High Residue Farming series







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This is the fifth in a series of publications on High Residue Farming under Irrigation. This publication provides an overview of strip-till, a **high residue farming** (HRF) practice, including its benefits and challenges. It also discusses some special considerations for high residue farming in the irrigated agriculture regions of the far western United States (the "**Far West**").

For anyone wanting to implement or know more about a high residue farming system, the series includes:

EM071—High Residue Farming under Irrigation: What and Why provides an overview of high residue farming (HRF), including its benefits and challenges. It also discusses some special considerations for high residue farming in the irrigated agriculture regions of the far western United States (the "Far West").

EM072—High Residue Farming under Irrigation: Crop Rotation covers choosing a cropping sequence, specific cover crops, and special considerations for irrigated cropping systems in the far western United States.

EM073—High Residue Farming under Irrigation: Residue Management through Planting explains how to plant crops into high residue conditions with a planter or drill. It covers residue management, planter and drill modification, and soil fertility adjustments.

EM074—High Residue Farming under Irrigation: Pest Management Considerations gives an overview of the effects of adopting HRF on the management of weeds, insects, and diseases.

High Residue Farming Under Irrigation: Strip-till

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After harvest of high yielding irrigated cereal crops, farmers in the western U.S. must manage large amounts of crop residues that remain in their fields. While there are benefits to leaving residues on the soil, including increased resistance to wind and water erosion, there are also problems. Residues make it more difficult to plant and cultivate, and residues also cool the soil, which can slow emergence of the next crop. Therefore, farmers have traditionally used numerous tillage operations to break up and bury these residues. Their goal is a seedbed with loose soil and little or no residue cover. This clean-till condition provides warmer soils and makes planting easier, but it also has several drawbacks. The loose soil left after tillage is easily compacted by heavy equipment. And bare, pulverized soil is vulnerable to wind and water erosion. Because of these problems and for economic reasons, farmers in the western U.S. have begun to implement high residue farming systems (Table 1). Strip-till is one of these systems.

The strip-till system creates both clean-till and high residue conditions, taking advantage of both systems while minimizing drawbacks. The soil is tilled and residue is either removed or buried in 6- to 12-inch-wide strips where the crop will be planted. The residue-covered area between these strips is left undisturbed (Figure 1). Strip-till is most easily implemented under sprinkler irrigation but may be adapted to other irrigation systems.

Figure 1. Strip-tilled row: tilled strips run between undisturbed ground covered by residue from the previous cereal crop.

Benefits

Benefits of the strip-till system are provided by both the bare, clean-tilled strips and the residue-covered strips (Morrison 2002).

Table 1. Tillage tools, tillage intensity, and resulting conditions in high-residue farming systems.

<table>
<tr><th colspan="2">Classification</th><th>Primary Tool(s)</th><th>Tillage Intensity</th><th>Residue Coverage</th></tr>
<tr><td colspan="2">Clean-till</td><td>Moldboard plow</td><td>High, soil inversion</td><td><30%</td></tr>
<tr><td colspan="2">Clean-till</td><td>Heavy offset disk</td><td>High</td><td><30%</td></tr>
<tr><td colspan="2">Reduced-till</td><td>Chisel plow, disk</td><td>High</td><td><30%</td></tr>
<tr><td>Reduced-till, Minimum-till, Mulch-till</td><td rowspan="6">High residue farming (Conservation tillage)</td><td>Chisel plow</td><td>Moderate</td><td>>30%</td></tr>
<tr><td>Strip-till</td><td>Strip-till implement</td><td>Non-uniform, moderate-none, 6–12” deep</td><td>60–80%, bare soil in planted strip</td></tr>
<tr><td>Zone-till, Vertical tillage</td><td>Gang of coulters on planter, row cleaners</td><td>Non-unifrom, moderate-none, 1–2” deep</td><td>60–80%, bare soil in planted strip</td></tr>
<tr><td>Direct seed, No-till*</td><td>Planter with row cleaners</td><td>None</td><td>60–80%, 0–80% in planted strip</td></tr>
<tr><td>Direct seed, No-till*</td><td>Planter without row cleaners</td><td>None</td><td>80–100%</td></tr>
</table>

*Direct seeding and No-till refer to the same practice.

Cover photo: Planting corn into alfalfa in the Columbia Basin of Central Washington. Photo by Andy McGuire.

Strip-till Benefits

From tillage and moving residue off strip

- Warmer soils at planting
- Alleviation of surface compaction
- Faster germination and early corn growth
- More options for fertilizer placement
- Reduced time and labor needs for tillage operations

From crop residue

- Reduced wind erosion
- Increased water infiltration
- Reduced evaporation
- Cooler soils in summer

With the residue removed, the bare strip receives more sunshine, resulting in warmer, dryer soil. This, in turn, promotes more rapid germination and emergence, especially of early spring-planted crops.

The soil warming is primarily due to the removal of residue and the resulting exposure to sunlight, rather than due to tillage. The graph in Figure 2 shows average daily soil temperatures at planting depth (2 inches) in a sandy soil in the northern Columbia Basin in 2009. The difference between tilled and untilled bare soil was negligible. The factor producing the largest increase in soil temperature was the removal of residue. If warmer soils are the main goal, it may only take removing the residue over the row to warm soils comparable to clean-tilled soils (Kaspar and Erbach 1990).

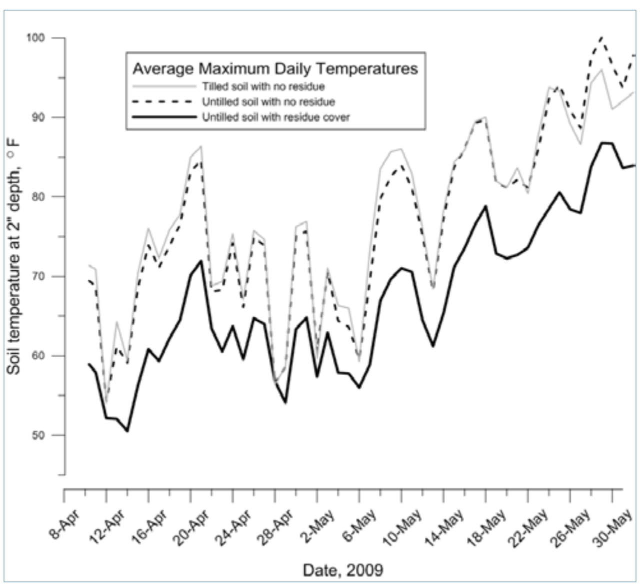

Figure 2. Plot of average daily soil temperatures in the northern Columbia Basin.

Tillage within a strip can loosen compacted soil, increase aeration, and improve drainage. In compacted or heavy, poorly drained soils, these changes can lead to improved crop root growth (see the discussion of compaction in the *Fit in Western Irrigated Agriculture* section, below). Finally, the bare strip allows easier planting with little or no planter modification needed.

Between the planted rows, the high residue conditions provide benefits. Crop residues provide a physical barrier that greatly reduces or eliminates wind erosion. The residue strips are especially effective if they are at right angles to the prevailing winds. In high wind events, strip-till eliminates the need to irrigate just to keep the soil from blowing, and this prevention of blowing soil protects newly emerged crops.

Residues also cushion the soil surface against the impact of falling water and prevent associated crusting. That, combined with increased soil aggregation from increased surface organic matter levels, can increase water infiltration rates. This, in turn, can reduce surface runoff and associated water erosion, and can increase uniformity when chemigating. These benefits are especially important under the outer spans of center pivots, on sloping land, and during intense rainstorms.

Reduced evaporation is another effect of residues covering the soil. Evaporation is reduced because residues block sunlight and restrict airflow at the soil surface. In arid climates with high evaporation potential, the management of this soil–air interface determines how water travels to the atmosphere. Research with strip-tilled cotton (Lascano et al. 1994; McVay and Olson 2004) found that the water saved by reduced evaporation in strip-till was instead used in plant transpiration. This increase in transpired water resulted in an equivalent yield increase. Although in fully irrigated crops we would not expect a similar yield increase, the increase of water use efficiency can still save water and associated pumping costs.

Finally, over the long term, eliminating tillage on most of the field will improve soil quality. As organic matter increases at the soil surface, so too does soil aggregation, water infiltration, and soil tilth. Soil crusting may be decreased, and earthworms, which prefer undisturbed soils, can increase in number.

The combination of these soil benefits often results in strip-till yields that are equal to those produced by clean-till systems (Vetsch J.A. and Randall G.W. 2002). Studies comparing yields of strip-till and no-till corn find that the results depend on the soil, climate, and crop details. Strip-till yields are better than no-till yields, more often, in these conditions: 1) early planted corn; 2) a wet, cool spring season; and 3) in northern growing areas (Randall and Hill 2000). However, in light textured soils, in warm, dry spring seasons, and after low-residue crops, strip-tilled corn has not shown consistent yield benefits over no-till corn. Midwest corn research (in the mid-latitude corn belt) has shown that in dry spring seasons, no-till systems perform just as well as strip-till in well-drained soils (Randall and Hill 2000). Similarly, in later planted crops such as dry beans, when soil temperature is not a factor, strip-till often loses its yield advantage.

Farmers can also use strip-tillage to help them manage uneven distribution of crop residue that is difficult to deal with in direct-seed/no-till systems. Using strip-till in this way can eliminate several primary and secondary tillage operations, thereby saving time, fuel, and equipment wear and tear. Also, more double-cropping opportunities become available as seedbed preparation between crops is minimized. Compared to tillage-intensive systems, the workload with strip-till may be more evenly distributed throughout the growing season. Future fuel prices are unpredictable, so reducing fuel use is always a good idea. Savings on fuel (from reduced equipment use) will vary with the crop and previous practices. Regarding equipment, selling the idled tillage machinery will bring the largest savings. If the equipment is still needed for other crops, savings will only be from reduced maintenance costs.

Finally, an important "multi-tasking" benefit of the strip-till system is the opportunity it presents for simultaneously banding nutrients. Liquid or dry fertilizers are easily banded at desired depths using the strip-till equipment described below.

Equipment

To obtain strip-till's combination of bare tilled soil and undisturbed crop residues, a standard lineup of tools is used. Numerous variations in layout and setup exist (see list of manufacturers, below), but the basic components are shown in Figure 3 and include:

- a leading coulter;
- a tillage shank;
- a pair of covering disks (also called berm builders).

Optional tools include row cleaners, auto-reset and fertilizer application tubes for the shank, and soil conditioners. Each component is described below.

A large (18–24 inches in diameter) coulter, usually smooth, cuts the residue and loosens the soil in a row. Some coulters have depth wheels and some are spring-loaded. They are located before, or occasionally behind, row cleaners. Often the coulters are attached to parallel links so they can roll over any rocks.

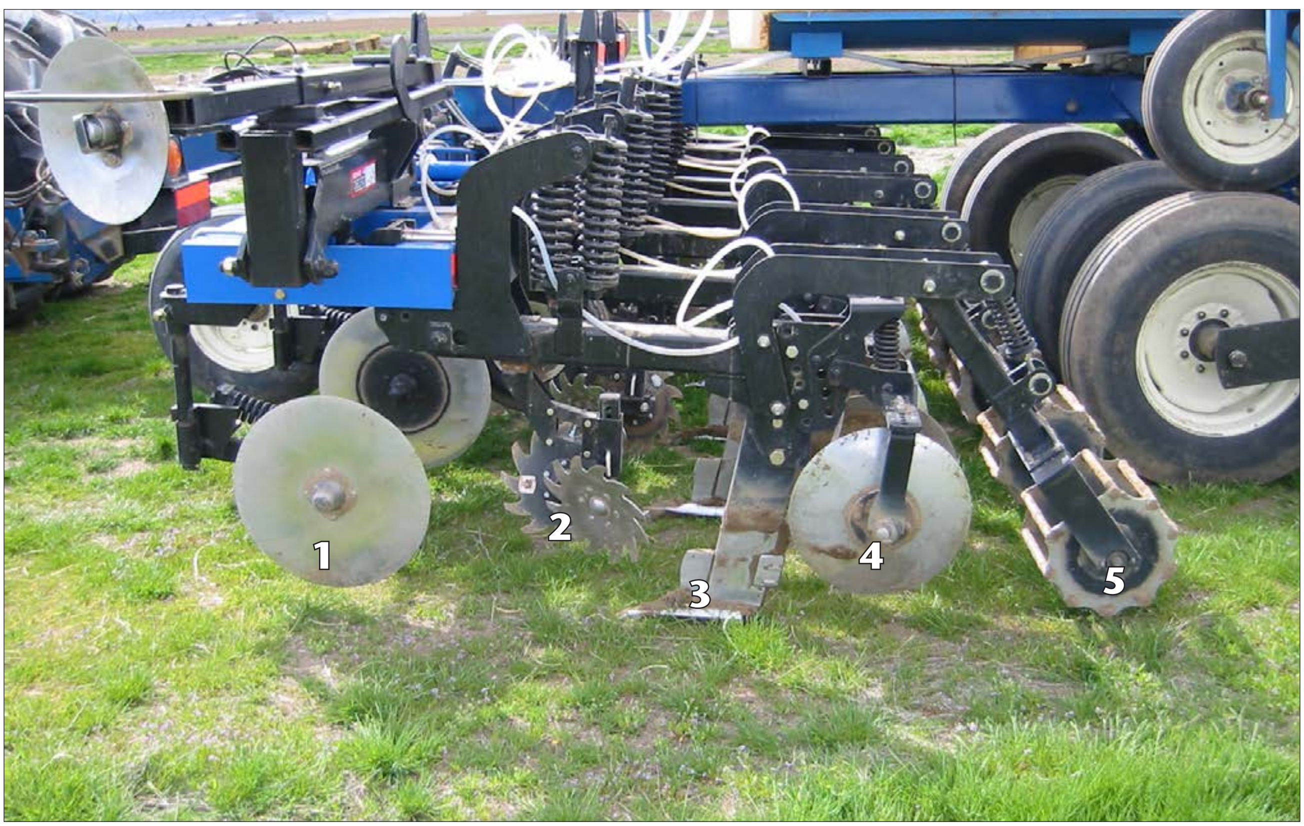

Figure 3. Components of a strip-till implement shown here include (1), a coulter; (2) row cleaners; (3) a tillage shank; (4) a pair of covering disks or "berm builders"; and (5) soil conditioners. The leading edge of the equipment system shown is to the left. See text for discussion of the components.

Figure 4. Various options for tillage shanks include a mole knife (A), and parabolic shanks (B, C).

Row cleaners remove residue from the strip of ground to be tilled. For long residue such as unchopped corn stalks, row cleaners work best behind the coulter. For shorter, more fragile residue, row cleaners can be placed either before or after the coulter.

The tillage shank both tills the soil and moves or buries any remaining residue in the strip. These shanks range from mole knives on straight shanks used in anhydrous ammonia application to large parabolic shanks used for deep ripping (Figure 4). Shank tips are designed to fracture the soil upward without inverting it. The depth of tillage is adjustable from 2 to 12 inches or deeper. Auto-reset systems for the shanks are available for use in areas where rocks are common.

Fertilizer application options depend on the crop, soils, and machine setup. Both dry and liquid fertilizers containing various combinations of N, P, K, and micronutrients can be injected (Figure 5). Some machines allow application of two different fertilizers at two adjustable depths while others allow only one depth. These systems are often customized by farmers for their own purposes after purchasing the equipment.

Figure 5. Fertilizer application components (hoses) mounted on a tillage shank.

Just behind and to either side of the shank are two 17- to 20-inch disks. These "covering" disks catch soil coming off the tillage shank and direct it back to the strip. They can be positioned either concave–side in or out, depending on the goals of the user.

Figure 6. Soil conditioners used on strip-till implements are available in many shapes and sizes for the wide variety of soil types and desired conditions.

Partial list of strip-till equipment manufacturers

(No endorsement is intended.)

- Bigham Brothers
- Blu-Jet (Progressive Ag Systems)
- Brillion Farm Equipment
- Case IH/DMI
- Dawn Equipment
- Hiniker Equipment
- John Deere
- Nitrotill (Ag Systems)
- Orthman Manufacturing
- Progressive
- Redball
- Remlinger
- Schlagel Manufacturing
- Soil Warrior
- Twin Diamond Industries
- Unverferth
- Wil-Rich
- Yetter

Finally, rolling baskets or some other type of soil conditioners can be used (Figure 6). These break up clods and prepare a smooth, firm seedbed for planting.

Management

As with the equipment, there are many options in strip-till timing and methods. Factors include time and machinery availability, custom farming options, crops, and climate. The two timing options are fall and spring. Fall strip-till requires a two-pass system while spring strip-till can be accomplished using either a one- or two-pass system.

Farmers often use fall strip-tillage to dry and warm heavy, poorly drained soils. Here the goal is to build a 3- to 4-inch mound that settles over the winter, leaving a slightly raised, mellow seedbed for spring planting.

Many farmers find that they can gain the same benefits by strip-tilling in the spring using one or two passes. In a one-pass system, the planter is attached behind the strip-till implement (cover photo). However, this will increase horsepower requirements and may also require a large stabilizing coulter on the planter to keep its wheels from drifting into the soft rows (a problem that can also affect following operations such as spraying).

Choice of operating speed is also more difficult with a one-pass system. Strip-till implements generally work best at 5.5–6.5 mph, while planters work best at 5 mph or less. Farmers often compromise and run at 5 mph.

In two-pass systems, for either spring or fall, it is important to plant down the center of the tilled strips to take advantage of the loosened soil. Because this is difficult to do manually, a GPS (global positioning system) guidance system is recommended. The most accurate RTK (real-time kinematic) systems give the best results but are also the most expensive. If you already have GPS guidance, consider strip-till as a value-added opportunity for your GPS investment.

With the spring two-pass system, strip-till and planting can be separated by several weeks or just a few days. Both operations may be done by the same person or one or both operations hired out. In the latter case, planting in the center of the strips requires that both operators use the same guidance system or that the strip-till machine and planter row spacing match well.

When choosing between spring and fall strip-till, consider your soils, your availability of time and equipment, and your goals. In light textured, well-drained soils, soil temperatures at planting in strip-tilled fields are about the same in the fall as they are in the spring (Figure 7). Creating the strips in the fall can be an advantage, though, because the soil is generally drier than in the spring. The drier soil will fracture better, alleviating any compacted areas. If the soil is too wet when strip-tilled, instead of fracturing the soil, the shanks will create a slot or even compact the soil

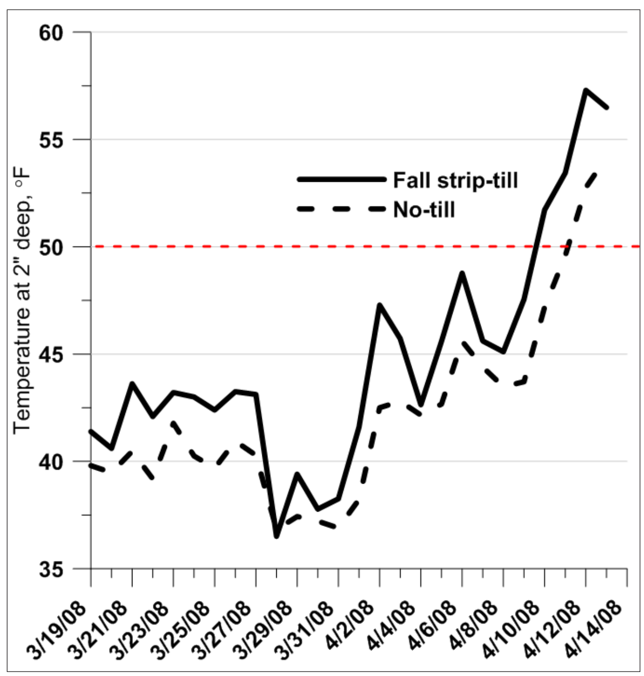

Figure 7. Soil temperatures of fall strip-till and no-till fields at planting depth in the spring.

Challenges

While strip-till avoids several of the drawbacks of direct seed/no-till systems, it does have its own challenges:

- Heavier soils may be prone to crusting within the bare, tilled strip.
- Water erosion can be a problem when strips are oriented up and down slopes instead of across slopes.
- Wind erosion can be a problem when wind direction and strip direction coincide.
- Rocky ground may be better suited to direct seed systems.
- In dry spring seasons, spring strip-tillage can result in an excessively dry seedbed which may require earlier irrigation.
- Banding of fertilizer creates non-uniform conditions. This demands more extensive soil sampling for fertility analysis.
- Strip-till implements cost as little as $1000 per row for a home-built machine and range from $2000 to $3000 per row for manufactured machines.
- The horsepower requirements of strip-tillage ranges from 15 to 30 hp per row.
- Strip-tillage eliminates cultivation as a weed control method.
- Tillage, even though limited to part of the field, still reduces soil quality and often leads to re-compaction. (See compaction discussion in the section, *Fit in Western Irrigated Agriculture*, below.)

between strips. Finally, some farmers find that they have more time to strip-till in the fall than in the spring.

Fit in Western Irrigated Agriculture

Strip-till fits well into several western irrigated agriculture situations, especially when compaction is a problem.

Following processed vegetable production, fields may be compacted from the traffic of heavy harvest equipment. Strip-till can help alleviate this compaction and quickly ready the field for planting the next crop. Fields grazed over the winter may also suffer from compaction and non-uniform distribution of residues. Strip-till addresses both of these issues.

Where it is reasonable to assume compaction problems exist, strip-till is a logical choice. However, where compaction problems are unknown or may only be suspected, the choice is more difficult. Unnecessary tillage is expensive, degrades the soil, and should be avoided when possible. When compaction is minor or unknown, consider no-till cropping systems or at least reducing the amount of tillage done in strip-tillage.

Over the last 40 years with the production of many crops in many regions, farmers have successfully developed various direct-seeding/no-till systems. The main challenge for these systems, assuming compaction is not a problem, is presented by crops that are sensitive to cold soil temperatures but need to be planted early. Corn is the most common example. The solution is to allow the soil to warm to near clean-till levels by moving residues without tillage. Most strip-till implements can be adjusted to clear residues with little or only shallow tillage. Zone-tillage implements are also available to provide shallow tillage and move residue. Some farmers have done the same thing using an empty planter in a two-pass system or by using row cleaners in a direct-seed system.

If you decide that tillage is needed, strip-till allows you to both till where it will do the most good—right under crop plants—and limit tillage's detrimental effects to only a portion of the soil. Still, you should have a plan to avoid the need for deep tillage in the future. Consider that strip-till can also provide an exit from the tillage-compaction cycle. Tilled soils are highly susceptible to re-compaction. This is why the benefits of deep ripping are often short lived; further machine traffic or grazing animals recompact the loose, tilled soil necessitating further tillage. The only way to avoid this cycle is to help the soil reform good structure after tillage while avoiding re-compaction. In the case of strip-till, the plant roots of a vigorous crop like corn can provide the needed soil binding. Re-compaction is avoided by driving on the firm row middles (controlled traffic). In this way, a deep strip-till operation which alleviates compaction can lead out of the tillage-compaction cycle to a shallow or no-till system, with or without residue removal over the crop row.

Short-term leases often make direct seeding/no-till difficult or impossible because the condition of the field

Strip-tillage can help you manage:

- Non-uniform residue distribution
- High residue conditions
- Compaction from heavy equipment traffic or grazing livestock
- Quick transitions from harvest of one crop to planting the next
- Unknown condition of leased land

after harvest of the previous crop is out of your control. The residue may be distributed non-uniformly and, also, you may not know the extent of compaction. Strip-till can be used to manage these variable conditions.

Strip-tillage is most common with crops grown on 30-inch row spacing. It can be adapted to row spacing down to 20 inches, but is more difficult at the narrower spacing because of the reduced area for residues. Grain, sweet corn, dry beans and green peas have all been successfully strip-tilled. Customized strip-till systems have also been developed for onions, sugar beets, cotton, and tomatoes.

How to get started

The best way to get started in strip-tillage is to learn about how the system will work on your farm. There are several ways to do this without buying a strip-till implement. First, check to see if there is a custom strip-tiller in your area. By hiring someone to strip-till, or strip-till and plant, part or all of one of your fields, you will better understand how the practice works in your conditions. Then you can make better decisions about whether it will work for you and what features you might need in a strip-till implement. Another alternative is to rent a strip-till implement, either from a dealer or local farmer. Finally, if you do not have significant compaction problems, consider using your empty planter as a type of strip tiller. With coulters and/or opening disks and row cleaners, the empty planter can clear a strip of soil before planting and give you an idea of how the practice works with your crops and soils.

To help decide whether the purchase of a strip-till machine makes economic sense, use the partial budget form provided at the end of this publication. If the numbers are not encouraging, consider strip-tilling more acres or doing custom strip-tilling work. These extra acres may balance the equipment expense sooner than farming only your own crops.

Finally, do not overlook programs provided by your local conservation districts or the USDA Natural Resource Conservation Service. They may have programs that offer low interest loans for strip-till equipment or payments for using the practice on your farm. Call your local USDA Farm Service Center to learn more about funding options.

Budgeting for a Strip-till System

Economics of Strip Tillage

The Partial Budget form, shown below, illustrates how to determine strip tillage costs and benefits, compared to conventional tillage. Choose a crop sequence, put in your estimates and see how strip-till compares. Include only those items that will be added or eliminated due to the change to strip-till. Include fixed, variable, fuel, and labor costs associated with each change. Use custom farming rates or estimates found in Extension publications if needed. Because strip-till can be implemented in so many ways, the results will be highly dependent on the specifics of individual operations.

Reduced costs are those current costs that would be eliminated in a strip-till system. Include the costs of owning tillage equipment, if there are implements you will no longer need in your operation.

Additional costs are those that come with use of the strip-till system. This includes purchase or lease of a strip-till implement or the cost of hiring someone to do the strip-tillage. It also includes any costs associated with changes in pest control resulting from the change to strip-till.

This form assumes that the strip-till system is managed to produce crop yields equal to your current tillage system (that is, revenue from sale of crop remains the same). Although this may not happen the first year strip-till is used, because of the learning curve, results in many regions indicate this is a reasonable assumption.

In addition to the net change in profit, you should consider other factors in evaluating a change to strip-till. These include possible increased risk, capital requirements, and the learning curve of optimizing strip-till in your operation. You must also evaluate the opportunities for using the time saved with strip-till. With this time, you could farm more acres, spend more time on other crops, or engage in other profitable activities (fishing, etc.). Finally, don't forget the value added by reduced wind erosion, reduced crop damage due to wind erosion, reduced need to irrigate during

Partial Budget comparing current system to strip-till planting	
Reduced Costs due to Strip-till	**Total**
Plowing	
Disking	
Cultivation	
Fertilizer	
Other:	
A. TOTAL reduced costs	
Added Costs from Strip-till	
Herbicide application	
Strip-tillage	
GPS guidance	
Seed	
Other:	
B. TOTAL added costs:	
Net change in profit (A minus B):	

windstorms, and improved soil quality. Although it is difficult to put dollar numbers on these benefits, they should factor into your decision as well.

The resulting net change in profit, if positive, can then be used with the number of acres farmed to calculate annual savings and how long the strip-till equipment will take to pay for itself.

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Funding provided by USDA-NIFA through the Columbia Plateau PM10 Project, http://www.pnw-winderosion.wsu.edu/.

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EM036E