Strip tillage for high-residue irrigated cropping systems

O. Steve Norberg

Strip tillage is a conservation tillage system that was developed for row crops grown in heavy, poorly drained cool soils in the northern corn belt states, but which some Pacific Northwest farmers are adapting to their local conditions. Strip tillage is designed for row crops in which only a 9–12 inch wide strip is tilled and planted and the ground between rows is left undisturbed (figure 1). The depth of tillage varies with producer and equipment but can be up to 14 inches deep. Growers are currently adapting strip tillage technology to a variety of row crop production systems in the Pacific Northwest.

Strip tillage, also referred to as zone or vertical tillage, offers many environmental and economic advantages to growers over conventional tillage, including the following:

- Increased profit per acre by eliminating several tillage operations.
  - Decreased fuel costs.
  - Decreased labor costs.
  - Decreased machine maintenance costs.
  - Decreased time per acre, allowing more acres to be farmed or allowing more personal time.
- Ability to deep band during the strip tillage operation, reducing phosphorus and potassium losses via surface water runoff.
- Benefits of less soil movement (soil stirring).
  - Increases water infiltration rates, which decreases runoff due to greater aggregation of soil particles and increased number of large water flow paths created by roots and worms.
  - Increases organic matter levels of the soil (improving soil tilth) by incorporating less oxygen in the soil and slowing microbial breakdown of organic matter.
- Benefits of increased residue on surface of the soil (percent residue cover).
  - Residues decrease soil sealing caused by energy of raindrop impacts tearing soil particles apart.
  - Creates irrigation water savings by decreasing soil water evaporation by residue reflecting sunlight, thereby cooling the soil and slowing air movement over the soil surface.
  - Reduces plant loss by blowing sand (wind erosion).

Figure 1. Corn planted using a strip tillage field near Jamieson, Oregon, under a center pivot. (Photo by O. Steve Norberg, © Oregon State University.)

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Strip Tillage Maintains Yield Levels

Strip tillage is a relatively new farming system, especially in the Pacific Northwest. Local research conducted on a farm in 2009 near Jamieson, Oregon, by Jensen and Norberg showed that yields of corn grown under strip tillage planted into wheat residue matched conventional yields and that six separate field operations, including two diskings, one field cultivation, fertilizer application, and a dammer-diker, were replaced with a flailing and a strip tillage operation (table 1). In Minnesota, research showed that strip tillage in a continuous corn rotation slightly reduced corn grain yield by 4 bu/a compared to conventional tillage and increased grain yield by 7 bu/a compared to no tillage (table 2; Vetsch and Randall 2002). After soybeans, corn yields grown under strip tillage matched conventional and no-tillage yields. Research from Iowa found no difference in corn yield between strip tillage, no tillage, and conventional tillage in a corn-soybean rotation (Al-Kaisi and Licht 2004). Research from 2004 to 2008 in Montana showed strip tillage in sugar beets after cereals maintained sugar beet yield (figure 2), sugar content, and sucrose yield as compared to conventional tillage (Evans et al. 2009). Five to seven tillage trips were eliminated by changing tillage systems to strip tillage in this study, showing that strip tillage is more economical. In summary, research has shown that strip tillage matches conventional yield levels.

Table 1. Yield and moisture of sprinkler irrigated corn on three different center pivots near Brogan, Oregon, in 2009.

<table>
<thead>
<tr>
<th>Location</th>
<th>Tillage type</th>
<th>Yield @ 15% (bu/a)</th>
<th>Moisture (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pivot 1</td>
<td>Strip tillage</td>
<td>247.4</td>
<td>27.0</td>
</tr>
<tr>
<td></td>
<td>Conventional</td>
<td>244.9</td>
<td>23.6</td>
</tr>
<tr>
<td>Pivot 2</td>
<td>Strip tillage</td>
<td>248.7</td>
<td>30.3</td>
</tr>
<tr>
<td></td>
<td>Conventional</td>
<td>254.7</td>
<td>27.6</td>
</tr>
<tr>
<td>Pivot 3</td>
<td>Strip tillage</td>
<td>272.3</td>
<td>25.7</td>
</tr>
<tr>
<td></td>
<td>Conventional</td>
<td>273.7</td>
<td>25.9</td>
</tr>
<tr>
<td>Average</td>
<td>Strip tillage</td>
<td>256.1</td>
<td>27.7</td>
</tr>
<tr>
<td></td>
<td>Conventional</td>
<td>257.8</td>
<td>25.7</td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td>NS</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Difference: Strip tillage minus conventional</td>
<td>–1.7</td>
<td>2.0</td>
<td></td>
</tr>
</tbody>
</table>

Note: NS = not significantly different.

Table 2. Corn yield (3-year average) by tillage and rotation in Minnesota. (From Vetsch and Randall 2002, used by permission.)

<table>
<thead>
<tr>
<th>Tillage system</th>
<th>Corn following corn (bu/a)</th>
<th>Corn following soybean (bu/a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No tillage</td>
<td>156</td>
<td>183</td>
</tr>
<tr>
<td>Strip tillage</td>
<td>163</td>
<td>183</td>
</tr>
<tr>
<td>Conventional tillage</td>
<td>167</td>
<td>182</td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td>3.2</td>
<td>NS</td>
</tr>
</tbody>
</table>

Note: NS = not significantly different.

More about Strip Tillage

Strip tillage and planting can be done separately in a two-pass system (figure 3) or in a one-pass system, often using a caddy to connect the strip tillage unit to the planter (figure 4). Auto-steer systems are generally used with both one- and two-pass systems. If planting is done in a two-pass system, strip tillage can be done in the fall or in the spring, right up to planting. As with any tillage, do not till when soils are too wet, because compaction may occur and reduce the effectiveness of strip tillage fracturing the soil. One advantage of the two-pass system is soil temperature. Strip tillage before planting moves the residue to the row middles, allowing the soil to warm up for planting. In heavy, wet soils it will take longer for the soil to warm than in dry, sandy soils. Strip tillage done in the fall may allow for an earlier
planting if soils remain wet in the spring. When considering timing of the strip tillage, consider issues like work load and cattle grazing. You do not want livestock in the field after strip tillage, as they will compact the soil in the strip and create problems.

Planting the seed accurately in the center of the tilled strip is essential to establishing a successful stand. With the one-pass system, the strip tillage unit is physically connected to the planter and makes this task easy. With the two-pass system, accurate planting can be precisely accomplished with the aid of an auto-guidance system. Currently, the most accurate method of accomplishing this is the real-time kinematic global positioning system (RTK GPS), which uses satellite and ground-based radio signals together to provide the differential corrections, which, depending on the system, can enable sub-inch accuracy (figure 5). However, less technical approaches (e.g., traditional marker strips placed on the soil surface) can be effective in some situations (figures 6 and 7). As with any tillage system, all components of the system must be in place to be successful.

When dealing with high-residue irrigated environments in the Pacific Northwest, handling the residue in a way that allows for successful seeding is a must. When harvesting the previous crop, using a chaff spreader to spread chaff back over the width of the combine header reduces problems with seedling emergence (figure 8).
Advantages of Strip Tillage Compared to Conventional Tillage

Compared to conventional tillage, strip tillage reduces water and wind erosion, especially in sandy soils, where stands can be lost each spring in wind storms. Strip tillage can greatly reduce this problem by leaving wheat stubble upright or by growing a cover crop and killing it prior to planting, both of which reduce soil movement and protect young seedlings (figure 9).

Strip tillage reduces soil stirring compared to conventional tillage, which improves soil organic matter content and reduces CO₂ losses from the soil (USDA Natural Resource Conservation Service n.d.). Keeping residue on the soil surface helps prevent snow from blowing away and reduces soil evaporation to the atmosphere. Reducing tillage reduces the labor and fuel required per area cropped. Crop residue provides food and protective cover for wildlife. Some day you may even get sellable carbon credits associated with strip tillage and carbon retention.

Water savings is another potential advantage of strip tillage. Research from the arid state of Texas on strip tillage in cotton production showed that strip tillage compared to conventional tillage reduced water loss from the soil (evaporation) by 39%, saving 2.5 inches of water (Lascano et al. 1994).

Disadvantages of Strip Tillage Compared to Conventional Tillage

To be successful, strip tillage will require more management, skill, and planning than conventional tillage. Conventional tillage stirs the soil more thoroughly, incorporating more residue than strip tillage and making planting easier. Conventional tillage does not require as precise driving when planting. Conventional tillage may allow more flexibility in timing for weed control; however, if herbicide-resistant varieties of crops are available, this
is not much of an issue. Thus, for strip tillage, different management practices and knowledge will likely be required in the areas of residue management, weed management, and seed placement with planter (figure 10). Cooler soil temperature in the spring is one of the problems with leaving residue and not tilling. However, fall strip tillage can eliminate this problem. Research has shown that removing residue has a larger impact on warming soils than tillage (Kaspar et al. 1990; McGuire 2009; figure 11). Row cleaners put on the strip tillage unit and planter can help move any residue away from the seeding area (figures 6 and 12).

Further research needs to be done to determine the influence of timing of strip tillage on crop growth and yield for different soil types and residue levels. In the one-pass strip tillage system, soil temperatures may be cooler during germination, resulting in slower plant emergence. Under these conditions, plant stress may increase seedling diseases and nutrient deficiencies.

Figure 10. Misalignment of the planter with the tilled strip can inhibit establishment of the seedling. In this picture the planter was left of the strip tillage row and planted in the residue, reducing the corn population. (Photo by O. Steve Norberg, © Oregon State University.)

Figure 11. Effect of removing residue and tillage on increasing soil-growing degree day accumulation in corn. (From McGuire (2009), used by permission.)

Figure 12. Row cleaners (or residue managers) mounted on the front of the planter unit help move the residue away from the planted area. The row cleaners should be adjusted down just enough to move the residue away without taking along very much soil. (Photo by O. Steve Norberg, © Oregon State University.)

**Strip Tillage Joins Benefits of No Tillage and Conventional Tillage**

Strip tillage offers a compromise that retains most of the advantages of no-till planting but also addresses conditions that local farmers cannot control, such as compaction and nonuniform residue distribution caused by harvest, compaction-prone sandy soils, and short-term land leases. Strip tillage enables deep ripping to remove hard pans and provide an area for the roots to penetrate vertically. It also allows fertilizer to be applied
below the surface. If the strip tillage operation is done before planting, soil temperatures are higher compared to no-till soil and provide better stand establishment (figure 13). Strip tillage does not stir the soil as much as conventional tillage, but does so more than no-till. In general, tillage should be done only when necessary, because tillage negatively impacts desirable soil properties (e.g., soil structure), decreases surface soil moisture, decreases water infiltration rates, and increases sealing of soil by rainfall or irrigation.

**Pointers That Will Lead to Success**

- **Select suitable fields.** Strip tillage is not suitable when proper residue management has not been done on the field. For example, significant piles of chaff will likely reduce stands. Fields that were left in bad condition, such as those with deep ruts from a wet harvest, may require conventional tillage before or instead of strip tillage. Strip tillage after other tillage may not work as well, since it was designed to work in a firm field.

- **Manage residue.** Planning your future crop rotations will help you avoid problems. When harvesting the crop previous to strip tillage, ensure that residue is evenly spread. Many times leaving the residue attached to the ground will aid in reducing plugging of strip tillage equipment. Residue levels may become more than strip tillage and planting can handle especially in small-seeded crops. In these situations, consider grazing, baling, or use of a rolling stalk chopper or turbo till to reduce size and total amount of residue. All these methods are accomplished without stirring the soil aggressively and will assist in keeping residues to a workable level. If you are going to graze cattle on the residue, be aware that volunteer wheat root mass may be significant enough to cause issues with spring strip tillage. A timely herbicide application may reduce problems next spring.

- **Power needed.** Up to 30 horsepower per row may be required. Horsepower requirements depend on the type of tillage unit, shank depth, soil moisture, and speed of tillage. For best results, follow manufacturer recommendations.

- **Invest in a quality machine.** Strip tillage is still a relatively new concept and advances in machines may help your strip tillage succeed. Also, if a large area will be covered, a RTK GPS system will likely be beneficial, since tolerances are less than 1 inch.

- **Allow more time for learning a new farming system.** Start with managing the residue of the previous crop and then work out your whole crop rotation.

- **Stay on the row.** Planting in the center of the strip tillage row will be worth your time, effort and money.

- **Apply fertilizer in row.** Producers should take advantage of being able to deep-band nutrients, especially immobile nutrients in the soil, such

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**Why Intensely Irrigated Areas Have Been Slow to Adopt Reduced Tillage**

Residue can interfere with water movement in corrugates or furrows, causing irrigation management problems, nonuniform irrigation, and likely reduced yields. Sprinkler-irrigated areas do not have this problem. Strip tillage works with furrow irrigation when all the residue is removed with crops such as alfalfa and corn silage. Small-seeded high-value crops require better seed to soil contact than large-seed crops and require more management when considering strip tillage. To help keep residue from reducing seed to soil contact, consider placing row cleaners in front of the strip tillage shanks (figure 6), as well as in front of the planter (figure 12). To reduce risk associated with the strip tillage, start with a small acreage until you have worked out system issues. This may mean borrowing equipment or contracting with someone with experience until you get the problems worked out.

![Figure 13. Comparison of soil temperatures in no-tillage and fall strip tillage systems. (From McGuire (2008), used by permission.)](image-url)
as phosphorus and potassium. Deep banding will increase efficiency and reduce phosphorus losses in runoff to surface water. Application of immobile nutrients can be done in the fall, when more time may be available. Tubes for liquid (figure 14) or dry fertilizer (figure 6) are placed down each ripper shank.

- **Avoid compaction in strip tillage row.** When applying herbicides or other applications after strip tillage, avoid compaction in the row as much as possible, because you will have a strong impact on your seed bed. When applying herbicide, consider applying it perpendicularly to the strips in the field.

- **Row cleaners on planters.** Use residue managers to move any residue off the row.

- **Don’t conduct strip tillage or plant when it’s too wet.** Conducting stripping tillage when it is too wet will cause compaction (at the depth of the shank). Planting when it is too wet will cause sidewall compaction (smear the sidewalls), which may inhibit root growth and reduce yields.

- **Anticipate new weed problems.** You may need to select a different herbicide to combat weeds that were normally controlled by tillage. Especially keep an eye out for an increase in perennial weeds.

- **Crops to consider under strip tillage.** When just starting strip tillage, it is easier to start with a large-seed crop, such as corn. Sugar beet and other small-seeded crops require a cleaner strip to plant. Cutting wheat or barley stubble 8 to 12 inches and baling is helpful when growing sugar beets.

- **Clay soils.** Strip tillage on clay soils, when soil moisture is too dry, causes clods. Strip tillage when soil moisture is too wet causes compaction and smearing. Fall strip tillage allows time for clods to break down and for the strip to become mellower with freezing and thawing over winter. Clods may be an issue where wheel traffic has compacted soils.

- **Planters seeding depth gauge wheels.** Depth wheels should be close to the place of seed drop. For small-seeded crops, depth wheels should be less than 8 inches from the seed drop to help adjust planting depth for undulations in strip tillage areas.

- **Seek information of producers who are already using strip tillage.** Finding producers who are currently using strip tillage will accelerate success by reducing the number of mistakes made during adoption.

### Economics of Strip Tillage

The calculations below illustrate how producers planting corn after wheat under a sprinkler irrigation system would compare the savings of strip tillage to conventional tillage. The example assumes that (1) the producer exchanges a rolling stalk chopper or turbo till and a glyphosate application for one disking to kill volunteer wheat after wheat harvest and (2) strip tillage eliminates plowing, another disking, fertilizer application, cultivation, and a dammer-diker operation. In addition, the cost of tillage and spraying used in this example came from the Malheur County Custom Agriculture Operators (Jensen 2010). Since no custom rate for strip tillage has yet been established, fuel and labor costs for operating a strip tillage unit were estimated, as was the calculated savings toward purchasing and maintaining a strip tillage unit. I estimate the cost of a six-row (30 inch rows) strip tillage unit at $30,000 plus an additional $20,000 for RTK GPS. Yearly payments including GPS would be $13,192 for five years (total cost $65,960), which includes 10% interest. An eight-row unit would probably be a better fit for 500 acres, but we used a six-row unit for our example. Strip tillage, the number of rows, and the width per row must match your planter and the horsepower of your tractor.
Table 3. Partial budget for changing to a corn strip tillage system after wheat.

<table>
<thead>
<tr>
<th></th>
<th>Labor and Machinery</th>
<th>Herbicide and Fuel</th>
<th>Total</th>
<th>Your Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reduced Costs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disking</td>
<td>$18.00</td>
<td></td>
<td>$18.00</td>
<td></td>
</tr>
<tr>
<td>Plowing</td>
<td>$30.00</td>
<td></td>
<td>$30.00</td>
<td></td>
</tr>
<tr>
<td>Disking</td>
<td>$18.00</td>
<td></td>
<td>$18.00</td>
<td></td>
</tr>
<tr>
<td>Groundhog</td>
<td>$18.00</td>
<td></td>
<td>$18.00</td>
<td></td>
</tr>
<tr>
<td>Fertilizer application</td>
<td>$9.00</td>
<td></td>
<td>$9.00</td>
<td></td>
</tr>
<tr>
<td>Dammer Diker</td>
<td>$13.00</td>
<td></td>
<td>$13.00</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td>$106.00</td>
<td></td>
</tr>
<tr>
<td><strong>Added Costs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rolling stalk chopper or turbo till(^1)</td>
<td>13.00</td>
<td></td>
<td>13.00</td>
<td></td>
</tr>
<tr>
<td>Spraying glyphosate</td>
<td>$9.00(^1)</td>
<td>$4</td>
<td>$13.00</td>
<td></td>
</tr>
<tr>
<td>Fuel and labor strip tillage(^4)</td>
<td>$3.50</td>
<td>$1(^2)</td>
<td>$4.50</td>
<td></td>
</tr>
<tr>
<td><strong>Savings per acre to pay for strip tillage unit(^3)</strong></td>
<td></td>
<td></td>
<td>$75.50</td>
<td></td>
</tr>
</tbody>
</table>

\(^1\)2010 cost for a custom application of glyphosate at 0.38 lb acid equivalent (a.e.)/acre. Herbicide portion $4/acre.

\(^2\)Fuel cost assuming 7 acres per hour and 1.7 gal/acre and $4 gal.

\(^3\)This operation is only necessary when residue is more than strip tillage and planting can handle. Custom rates for this application are still being determined.

\(^4\)No custom rate is available for strip tillage, so fuel and labor are separated, as is savings to apply to purchasing and maintaining the unit.

Table 4. Long term economics of changing to a corn strip tillage system after wheat.

<table>
<thead>
<tr>
<th>Number of acres per year using strip tillage</th>
<th>Amount saved per acre to pay for equipment</th>
<th>Total amount per year to service debt</th>
<th>Years to pay off strip tillage unit, applying all savings to debt</th>
<th>Life expectancy of unit (years)(^1)</th>
<th>Total savings after 10 years(^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>175</td>
<td>$75.50</td>
<td>13,213</td>
<td>5.0</td>
<td>80</td>
<td>$66,170</td>
</tr>
<tr>
<td>250</td>
<td>$75.50</td>
<td>18,875</td>
<td>3.5</td>
<td>57</td>
<td>$122,790</td>
</tr>
<tr>
<td>500</td>
<td>$75.50</td>
<td>37,750</td>
<td>1.7</td>
<td>28</td>
<td>$311,540</td>
</tr>
</tbody>
</table>

\(^1\)Life expectancy for equipment is generally estimated at 2,000 hours.

\(^2\)Savings, after purchase of strip tillage unit and carrying the loan all five years.

References


For More Information

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