EM 8824 • February 2003
$2.50

Using Strip Tillage in Vegetable Production Systems in Western Oregon

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What is strip tillage?

Strip tillage is a form of conservation tillage that involves tilling narrow strips for crop establishment while leaving areas between the strips with undisturbed crop residue (Figure 1). Strip tillage can reduce soil erosion and soil compaction, as well as machinery, fuel, and labor costs. Combined with winter cover crops, strip tillage also can dramatically improve soil quality.

Strip tillage combines some of the advantages of full-width, traditional tillage with those of no-till (direct-seeding) systems. Unlike no-till, however, where the seed is planted into narrow slits in the soil, strip tillage involves tilling a 6- to 12-inch-wide band, usually 8 to 16 inches deep. Traditional planters then are used to plant into the tilled strips.

Strip tillage involves the substitution of strip-till equipment for conventional tillage equipment. It involves changing several cultural practices for optimum results.

Figure 1.—A strip-till system uses killed cover crops or crop residue as surface mulch. Standard planting equipment is used to plant into the tilled strips.

Oregon research in strip tillage

On-farm research was conducted in the Willamette Valley from 1996 to 2001 to compare strip tillage with conventional tillage systems. More than 30 large-scale field trials were conducted on a variety of soils and with different crop rotations. Trials were conducted primarily on sweet corn, but other vegetable crops were investigated as well. Commercial

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Figure 2.—Clods formed during the tillage process reduce soil quality during key times of seedling emergence and crop root development.

Figure 3.—Water runoff from fields during rainstorms can carry dissolved and suspended nutrients into surface water.

Figure 4.—Cover crops can provide soil cover, reduce erosion, and enhance both soil quality and productivity.

harvesting equipment was used. Sweet corn grade was determined by the cooperating food processing company.

Although yield differences between tillage systems occurred in individual fields, average sweet corn yields from strip-till fields were identical to yields from conventional tillage over the 5-year trial (Table 1) (Luna and Staben, 2002). Tillage and labor costs in the strip-till systems, however, were considerably lower than with conventional tillage (see below).

Although most on-farm strip-tillage research has focused on sweet corn production, several farms have used strip tillage successfully for production of squash, pumpkin, and transplanted broccoli and cauliflower. Other row crops that are planted on 30- to 36-inch row centers likely would be amenable to strip-till production, but seedbed preparation and weed-control practices would be more important for snap beans and other small-seeded crops.

Potential advantages of strip tillage

Strip tillage offers a potential "win/win/win" situation in terms of improving economic profitability, soil productivity, and environmental quality.

Cost savings

In the Oregon on-farm research trials, data were collected on actual tillage practices and costs on six fields. Strip tillage saved 43 percent in tillage costs compared to conventional tillage and 47 percent in labor costs to operate tillage equipment (Luna and Staben, 2002). It is important to note that these data are based only on "in-field" equipment use time, and do not include time and expense in moving multiple pieces of conventional tillage equipment among fields. Thus, these data underestimate the full cost savings from strip tillage where there is considerable distance between fields.

Soil quality improvement

Intensive tillage operations have been shown to reduce soil tilth through loss of structure, aggregate stability, and organic matter (Figure 2). Long-term studies of no-till systems have shown dramatic improvements in soil quality compared to conventional tillage. As a hybrid tillage system between no-till and conventional tillage, strip tillage can offer improvements in soil quality since about 50 to 70 percent of the soil surface remains untilled.

The reduction of soil compaction from heavy farm equipment is a major advantage of strip-till systems. Conventional tillage systems can involve four to eight passes over a field with tillage equipment. Strip tillage requires only one or two passes over the field. Also, in strip-till systems, tractor traffic is confined to the areas between the tilled strips, thus minimizing compaction in the planted crop row.

Strip-tillage systems can help preserve earthworms. In OSU research trials, strip tillage reduced mortality to the night crawler, *Lumbricus terrestris*, compared to conventional tillage. Beneficial soil-dwelling insects such as predacious ground beetles are conserved in strip-tillage systems. On the other hand, strip tillage can increase certain soil pests as well (see page 4).

Improved environmental quality

Soil erosion is a major source of contamination of surface waters. Extensive research from around the world has shown the dramatic ability of no-till systems to reduce both water- and wind-borne soil erosion. Strip tillage, as a hybrid tillage system with undisturbed residue areas between the tilled strips, can reduce soil erosion. Strip tillage also can reduce water runoff from fields, which can carry dissolved pesticides and soil-bound nutrients into surface waters (Figure 3). When used on highly erodible slopes, however, strip tillage should be used perpendicular to the direction of the slope wherever possible. Cover crops also are critical in preventing soil erosion (Figure 4).

Potential disadvantages of strip tillage

Cover crops can delay tillage operations

Cover crops generally keep the soil surface wetter than it is in fields without cover crops and can delay tillage operations for early-planted crops. If cover crops are used as part of the strip-tillage system, they must be selected and managed properly to minimize problems with early-season plantings.

Additional vegetation management costs

Two herbicide applications frequently are required to kill cover crops and weeds prior to planting in strip-till systems (see page 9), thus increasing production costs for the strip-tillage system.

Problems with uniformity in crop stand establishment and maturity

Problems have occurred in some sweet corn fields with uneven crop emergence, growth, and maturity. For machine-harvested crops for processing, uneven maturity can reduce grade and marketable yield. These problems have occurred because of rough, inadequate seedbed quality that sometimes results from a single-pass strip tillage operation. The use of second-pass strip tillage equipment (see page 5) has improved seedbed quality and generally eliminated uneven emergence and maturity problems.

Table 1.—Yield and tillage costs in Willamette Valley sweet corn field trials.

Tillage system	Graded yield[1] (tons/acre)		Tillage costs[2] ($/acre)	
	1997–1998	1999–2000	1997–1998	1999–2000
Strip till	8.9	8.3	$20.90	$14.30
Conventional till	8.6	8.3	$36.50	$29.10

[1]Number of on-farm trials for yield: 1997–1998 = 8; 1999–2000 = 12

[2]Number of on-farm trials for estimating tillage costs: 1997–1998 = 6; 1999–2000 = 5

Figure 5.—A Northwest Tillers strip rototiller was used in the 1997–1998 on-farm research trials in the Willamette Valley.

Figure 6.—Closeup view of the Transtiller strip-till machine, showing the front disk coulter with depth gage band, followed by the tilling shank, fluted coulters, and finishing basket.

Figure 7.—The Unverferth Ripper-Stripper strip-till machine is similar to the Transtiller, using a subsoiling shank and pairs of fluted coulters to prepare a seedbed.

Pest management

Shifting from conventional tillage to strip tillage can increase population levels of some pests. Sometimes, new pests appear that previously were controlled through conventional tillage practices. Modifications in pest management practices usually are required to make the strip-tillage system work. (See the section below on "Pest management considerations," pages 8–9, for specific concerns with strip tillage.)

Strip-tillage equipment

There are two main types of strip-tillage equipment: (1) a rotary strip tiller, and (2) a shank-coulter tiller. Strip-tillage machinery needs to be set up on the same number of rows and spacing configuration as the planting equipment so the planter will run precisely where the strips are placed. Heavy-duty "no-till" row markers or GPS-guided autopilots are essential to allow alignment of the tillage passes.

Rotary strip tiller

A rotary strip tiller is a modified tractor-mounted rototiller with sets of tiller blades removed and shields within the tub of the tiller to retain the soil within each tilled zone (Figure 5). A heavy-duty tiller is required for strip tillage into previously untilled soil. Existing rototillers can be modified in the farm shop, or factory-built equipment can be purchased (see Appendix). In the Oregon on-farm research project, a machine manufactured by Northwest Tillers, Inc., Yakima, WA, was used.

Shank-coulter tiller

This type of strip-tiller uses a front disk coulter with a depth wheel that cuts through crop residue and vegetation, followed by a subsoiling shank that operates to a depth of about 14 inches. A double set of fluted coulters mixes and chops the soil, followed by a clod-crushing basket (Figure 6). All components are mounted on a tool bar equipped with row markers (if required). In the Oregon on-farm research project, we used a privately built Transtiller (Figures 1 and 6) and a Ripper-Stripper machine manufactured by Unverferth, Inc., Kalida, OH (Figure 7). Several companies produce strip-till machines operating on the same principle (see Appendix).

Second-pass equipment

Research in western Oregon soils has shown that a single pass of the shank-coulter type strip-tillage machine frequently leaves a rough seedbed; a second tillage pass is needed to obtain a satisfactory seedbed. Various types of equipment have been used for the second pass, including a light-duty rotary cultivator commonly used for between-row weed cultivation (Figure 8). Specialized machines, which use combinations of straight disks, baskets, and rollers (Figure 9), have been manufactured by participating farmers. One of the farmers working on this project modified a Howard Rotospike tiller as a second-pass tillage tool (Figure 10, following page). This machine uses heavy-duty spikes rather than conventional rototiller tines. As described earlier, making a second pass in a strip-till system can dramatically improve the evenness of crop emergence and maturity, an important factor in producing uniformly maturing crops for the processing market.

Figure 8.—A light-duty rotary cultivator can be used for a second-pass tillage pass in strip-till systems to improve seedbed quality.

Finishing ring rollers

Pulling a finishing ring roller (also called cultipackers or Schmeiser rollers) as a final pass following strip tillage helps to smooth and firm up the seedbed (Figure 11, following page). Because strip-tillage equipment usually throws some soil into the untilled areas, a ring roller can smooth the field for subsequent operations.

Managing for success with strip tillage

Although on average, strip tillage produced yields similar to conventional tillage in the Oregon on-farm trials, many strip-tilled fields have produced higher yields than conventional tillage. High yields can be obtained with strip tillage by managing several factors, including soil compaction, previous cropping history, cover crops, weeds, pathogens, and insect pests.

By understanding the field conditions that favor strip tillage (and those that are unfavorable), you can apply cultural practices that improve the probability of success. You also might decide to use conventional tillage where strip tillage is inappropriate.

Figure 9.—One approach to second-pass equipment for strip-till is this machine, which uses a series of flat disks followed by a ring roller (designed by J. Hendricks and R. Heater).

Figure 10.—The Howard Rotospike tiller shown here has been modified with soil shields for use in second-pass operations in strip-till systems. The closeup view on the right shows the heavy-duty spikes, which are used instead of traditional L-shaped tines.

Soil compaction

Successive tillage operations tend to break down stable soil aggregates. Soil compaction, or a loss of soil pore space and an increase in bulk density, can result from repeatedly running over fields with heavy farm equipment. Soil moisture and soil type affect the degree of compaction that occurs with tillage and vehicular traffic. Wet soils are much more prone to compaction than dry soils. Clay soils are more susceptible to compaction than sandy soils.

Many processed vegetable crops are harvested when soils are wet, either late in the season after fall rains have begun, or following irrigation. Heavy tractors, harvest wagons, and trucks hauling full loads can compact soil severely.

Strip tillage generally has been less productive in highly compacted soils. In fields with known or suspected compaction problems, consider using conventional tillage. However, if weather permits fall subsoiling or other fall tillage to break up compacted soil, you can use strip tillage the following spring. Fall-planted winter cover crops (see right) also can alleviate soil compaction problems and prevent surface compaction from winter rainfall.

Figure 11.—A ring roller, or cultipacker, is a useful finishing implement in strip tillage. The rollers crush soil clods and smooth the soil surface.

Measuring soil compaction

A useful tool for assessing relative soil compaction is the DICKEY-john hand-held penetrometer (Figure 12) (see Appendix). The penetrometer measures the pressure of resistance to a probe being pressed into the soil. The depths and degree of compaction layers can be observed.

When using a penetrometer, be aware that measurements are relative to soil type and current moisture conditions. The penetrometer will give very different readings when the soil is moist than when it is dry. But with experience, the penetrometer can provide useful information about the relative degree, location, and depth of compaction in fields.

Previous cropping history

Crop rotation has been shown to be important for weed, disease, and insect management. Previous cropping history can have dramatic effects on the physical conditions of the soil. As described above, good soil tilth is essential for success with strip tillage.

Prior wheat or other small grain fields that have gone through the winter with straw residue, stubble, and wheat regrowth are excellent for strip tillage. The soil in these situations has remained untilled for more than a year and has had a chance to "mellow" with the decomposing straw residue. Grass seed fields that have been in a seed crop for several years can provide good situations for strip till, although killing the existing grass crop with herbicides can be difficult. An application of glyphosate herbicide in the fall, after rains have promoted some regrowth, may improve the ability to kill the grass prior to strip tillage in the spring.

Cover crops

Cover crops traditionally have been planted to prevent soil erosion, but they offer many other potential benefits. These benefits include improving soil structure and fertility, weed suppression, habitats for beneficial organisms, and, in some instances, nematode and plant pathogen suppression (Sattell, 1998; Sustainable Agriculture Network, 1998).

Legume cover crops can produce from 50 to 200 pounds of nitrogen per acre, which can improve crop yields and reduce the need for purchased fertilizers. To obtain these levels of nitrogen accumulation, however, the legumes must be allowed to grow relatively late in the spring (May), which may create problems with excessive biomass (see below).

Winter annual cover crops usually are planted in late September or early October using a grain drill or by broadcast seeding. These crops establish in the fall and provide ground cover, preventing erosion through the winter. Rapid growth usually begins in late March or early April, depending on temperature and moisture conditions.

Timing of herbicide applications for killing cover crops or existing vegetation

Glyphosate herbicide typically is used to kill cover crops and other existing vegetation prior to strip tillage. Proper timing is important. If the cover crop is killed too early in the season, the relatively small amount of cover crop biomass will degrade quickly and little residue will remain during the growing season. If the cover crop is allowed to grow too long, there can be an excessive accumulation of cover crop biomass. Too much cover crop residue can clog the strip-till equipment, produce a poor seedbed, and reduce effectiveness of weed cultivation equipment.

Figure 12.—The DICKEY-john penetrometer is a useful tool for testing soil compaction at varying soil depths.

Typically, late March to late April is a suitable time to kill a cover crop prior to strip tillage in western Oregon. As a general rule, kill cover crops a minimum of 30 days prior to planting.

Quite often, a second application of glyphosate will be required after the strip tillage operation but just prior to planting the crop to kill weeds that have emerged since the first glyphosate application. This preplant application of glyphosate can be a key factor in successful weed management in strip-tillage systems.

Grazing cover crops?

Although winter cover crops can provide significant quantities of forage for livestock grazing, our experience has shown that soil compaction from the grazing animals can create problems for strip tillage. The compaction occurs primarily at the surface level, but can cause cloddy conditions, a rough seedbed, and uneven crop establishment.

Planting and fertilizing vegetable crops in strip tillage

Initial strip-tillage operations should be conducted at least 14 days prior to planting. Second-pass tillage operations can be made the same day as planting.

Standard planting equipment is used in strip-tillage systems. If you use side-banding fertilizer knives, you may need to adjust them to run within the tilled strip. Because the tilled strips usually provide excellent visual alignment for the tractor and planter, the row markers on the planter are not needed.

Pest management considerations

Insects

During the 6 years of on-farm trials comparing strip tillage and conventional tillage systems, sweet corn fields were intensively scouted for pest abundance and damage. There was little incidence of insect pest damage in any of the fields and no evidence that strip tillage either increased or reduced insect pest severity.

However, in two paired trials in 2001, outbreaks of the garden symphylan (*Scutigerella immaculata*) damaged sweet corn in the strip-tillage blocks more than in the conventionally tilled blocks. Tillage has been used historically as a cultural method to suppress symphylan populations. Clearly, fields having a history of symphylan damage should be scouted, and preplant insecticides may be necessary to prevent damage. (See the *Pacific Northwest Insect Management Handbook* (McGrath, 2002) for scouting methods and treatment thresholds.)

Pathogens

Sweet corn yield decline syndrome is a condition affecting many sweet corn fields in the Willamette Valley. This syndrome produces blackened, rotted roots and causes a yellowing and "firing" of corn leaves, diminished ear size, and reduced overall yield. It is linked to several soil pathogens, and research currently is underway at Oregon State University to help growers overcome this problem. In studies in 1999, corn root rot was monitored in strip tillage and conventional tillage fields, and no correlation of the syndrome with tillage method was found.

Weed management

Strip tillage increases the level of management required for successful weed control. The tilled and untilled areas favor different weed species, necessitating different management strategies than in conventional tillage.

As mentioned earlier in the cover crop section, the preplant glyphosate application can kill weeds (and surviving cover crop) that have emerged in the untilled strips. If there is enough time between tillage and planting to sprout weed seeds, this application also provides timely weed control in the tilled strip. This serves as a form of the traditional "stale seedbed" method of weed control used in conventional tillage systems.

Preemergent herbicides used in conventional tillage may be used in strip tillage. For materials that do not require soil incorporation, apply after the last strip tillage operation for maximum effectiveness. If soil incorporation is required, you can use a second-pass strip tillage operation to incorporate herbicides.

Some growers have reduced herbicide application rates by banding preemergent herbicides over the tilled strip and using cultivation for weed control in the untilled strips. Depending on surface compaction, soil moisture, and crop and cover crop residue, however, traditional cultivation equipment may not work as well as in conventionally tilled soils. Some growers use high-residue cultivators such as the Buffalo cultivator (Figures 13 and 14) (see Appendix). Postemergent herbicides can be important tools for weed management in strip-tillage systems.

Slugs

Because of the conservation of crop residue on the soil surface, strip tillage can enhance the habitat and survival of slugs, although slugs can be a problem in conventionally tilled fields as well. Scout fields for slug damage during crop emergence and early development. Apply slug baits if necessary to prevent economic damage.

While improving habitat for slugs, strip tillage also can conserve populations of predacious ground beetles (Carabidae). These beetles feed on slugs and may be important factors in biological control of slugs.

Patience and persistence: Keys to making strip tillage work

Strip tillage has shown the potential to reduce both production costs and environmental impacts. Strip tillage has been used for growing sweet corn, squash, and transplanted broccoli (Figure 15, following page).

However, making the transition to strip tillage represents a major systems change. There is a learning curve to be mastered before success is achieved. If you are considering strip tillage, talk with other growers who are using strip tillage and be willing to experiment. Start with relatively small acreage and borrow or rent strip tillage equipment if possible. Expect problems to occur until you have mastered the various facets of this new tillage system. Patience and persistence are key factors for success with strip tillage.

Figure 13.—Cultivation between rows is possible in strip-till systems using conventional cultivation equipment. The Buffalo cultivator (shown here) is designed to operate in high-residue conditions.

Figure 14.—Components of the Buffalo cultivator that allow it to operate in high-residue conditions include a rolling disk coulter to cut through residue in front of the heavy-duty sweep cultivators.

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Figure 15.—Strip tillage has been adopted for production of sweet corn, squash, and transplanted broccoli (shown here).

Acknowledgments

The collaboration of the following Oregon farmers is gratefully acknowledged: Carl, Jack, and Kenny Hendricks; Mike and Mark Dickman; Bill Chambers; Rob Heater; Steve and Alan Keudell; Rod Chambers; Larry and Ron Pearmine; Sam Sweeney; Ray Stafford; and Brent Westover. Financial support was provided by the Oregon Watershed Enhancement Board, the Oregon Processed Vegetable Commission, the USDA Sustainable Agriculture Research and Education Program, and the Oregon State University Agricultural Research Foundation. We also thank Dick Strunk and Northwest Tillers, Inc., Yakima, WA, for providing strip-tillage equipment.

Appendix. Equipment Manufacturers

DICKEY-john Corporation (Soil compaction tester), 5200 DICKEY-john Rd., Auburn, IL 62615
Phone: 800-637-2952; FAX: 217-438-6012; Website: http://www.dickey-john.com

Fleischer Manufacturing, Inc. (Buffalo cultivator), P.O. Box 848, Columbus, NE 68602.
Phone: 402-564-3244; FAX 402-562-6112; Website: http://www.agshow.com/tillage/html/body_buffalo.html

Kongskilde Industries (Howard rototillers), Skaelsksrvej 64, DK-4180, Sors, Denmark.
Phone: 45 57 86 50 00; FAX 45 57 86 51 00; Website: http://www.howard-int.com

Northwest Tillers, Inc. (Strip-till equipment), P.O. Box 10932, Yakima, WA 98909.
Phone: 509-452-3307; Website: http://www.nwtiller.com

Schlagel Manufacturing (Strip-till equipment), R.R. Box 155C, Torrington, WY 82240.
Phone: 888-889-1504; FAX: 307-532-8994; Website: www.schlagel.net

Unverferth Manufacturing Company, Inc. (Strip-till equipment), P.O. Box 357, Kalida, OH 45853.
Phone: 419-532-3121; FAX: 419-532-2468; Website: http://www.4unverferth.com

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Produced and distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914. Extension work is a cooperative program of Oregon State University, the U.S. Department of Agriculture, and Oregon counties.

Published February 2003.