Best Management Practices

STRIP-TILLAGE IN ONTARIO: THE BASICS

Conventional tillage and no-till systems are often compared in terms of crop production and their effects on soils and the environment. No-till has many benefits, including reduced erosion risk. However, no-till can be challenging to implement for some crops, especially corn, due to Ontario's cool, wet spring conditions. Likewise, conventional tillage provides early season soil warming and drying, but can degrade soil over time and leave it vulnerable to erosion from water and wind. It is also labour and fuel intensive. In recent years, many Ontario farmers have sought a middle ground between full tillage and no-till: strip-tillage.

Strip-tillage captures benefits of both conventional and no-tillage while minimizing the negative aspects of each. It delivers the soil warming and drying of conventional tillage with the soil protection of no-till through undisturbed soil left between strips.

Improvements in strip-tillage equipment and in global positioning systems (GPS) have enabled improved strip-till performance in recent years, which has increased its uptake.

THE ROLE OF HEALTHY SOIL IN A CHANGING CLIMATE

Agriculture and climate are directly linked – anything that has a significant effect on our climate will influence farm production. Greenhouse gas (GHG) emissions and climate change are global concerns, and agriculture can be part of the solution.

BMPs that improve soil health can also help lower GHG emissions, reduce phosphorus loss from fields to surface water, and improve resilience to drought or excessively wet conditions. Healthy soil – an essential component of a healthy environment – is the foundation upon which a sustainable agriculture production system is built.

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How does strip-tillage work?

Strip-tillage is a system that clears residue and tills strips in planting zones while leaving residue in-place and soil undisturbed over approximately two-thirds of the field surface. Strip-tillage is often done in the summer or fall after harvest, though many growers also prepare strips in the spring, particularly on light-textured soils. A slight elevation, or berm, is created in the fall strip to allow it to shed water and warm quickly. In some cases, farmers will perform fall strip-tillage followed by a light second spring pass to "freshen" the strips ahead of planting. Leaving undisturbed residue between the tilled planting strips is an excellent way to reduce risks of erosion, improve soil structure, enhance soil life and provide more stable footing for farm equipment.

Figure 1. Strip-tillage allows primary tillage to be combined with fertilizer application and secondary tillage (in one pass strip-tillage), which enhances cropping system efficiency.

Figure 2. Freshly made strips on an Ontario farm.

EQUIPMENT

Strip-tillage equipment comes in a range of configurations and sizes. While the components of each machine vary slightly depending on manufacturer, the general row unit configuration is as follows (Figure 3):

- a cutting coulter to cut through residue
- residue cleaners to remove surface residue from the strip
- a shank or tillage coulters to do the actual tillage
- working/containment coulters to build the berm and contain soil within the strip
- a finishing device, such as a rolling basket (optional) to condition the seedbed

Generally, a chunkier, elevated strip with larger aggregates is desirable in the fall. Such a strip is less vulnerable to erosion and freeze-thaw cycles over winter help break it down to a uniform, slightly raised seedbed come spring. It is important that the fall strip does not become a depression over winter. A finer, more level seedbed is the goal for spring strip-tillage.

Figure 3. An example strip-till unit. From left to right, each unit on this strip-tiller includes: 1) a cutting coulter, 2) residue cleaners, 3) a shank, 4) working/containment coulters and 5) a rolling basket.

Crops best suited to strip-tillage in Ontario

CORN

In Ontario, strip-tillage is primarily used for corn production, in part due to inherently wider row-widths. Early planting into drier, warmer soils is a primary advantage (Figure 4), while the ability to band or blend fertilizer within the stripped zone increases production system efficiency. In avoiding separate primary and secondary tillage passes, and in some cases, fertilizer spreading and stone picking, strip-till has resulted in significant labour, fuel and time savings on Ontario farms.

Early Ontario research found strip-till grown corn to yield similar to conventional systems on sandy loam soils, while clay and silt loams showed a yield reduction in some years[1]. Since strip-tillage was first promoted in Ontario in the 1990s, there has been a steady increase in the variety and quality of strip-tillage equipment available (Figure 5). Improvements in GPS systems on farm have enabled strip-tillers to accurately strip and stay on the strip while planting, which was an early challenge for the system. In recent years, many Ontario corn growers across a range of soil types report consistent yields when converting from conventional tillage to strip-tillage.

Figure 4. Strip-till corn. Tilled strips create drier, warmer soils that support fast early-season growth.

Figure 5. There is a wide variety of strip-tillage equipment available to Ontario growers, as profiled in this demonstration at Canada's Outdoor Farm Show.

(1) Vyn, T.J. and Raimbault, B.A., 1992. Evaluation of strip tillage systems for corn production in Ontario. Soil Tillage Research. 23:163-176. https://doi.org/10.1016/0167-1987(92)90012-Z.

EDIBLE BEANS

Strip-tillage is used for a variety of edible bean market classes in Ontario. Edible beans that are direct harvested, such as adzukis and white beans, are best suited to strip-tillage (Figure 6). Pulling and windrowing beans, where knives or rods run under the soil surface, may be difficult to produce in a strip-till system. Yield comparisons between strip-till and conventional tillage are not currently available; however, the practice is growing in popularity amongst edible bean farmers.

Figure 6. Strip-tilled, twin row white beans.

SOYBEANS

Strip-tillage is not commonly used for soybean production in Ontario. Provincial trials have consistently shown narrow rows out-yield wide rows, which limits strip-till's applicability. Its use is generally limited to row widths of 50.8 cm (20 in) or twin rows on 76.2 cm (30 in) centres.

HORTICULTURE CROPS

A strip-tillage system can fit with horticulture crops where row spacings of 50.8-76.2 cm (20-30 ins) or more are used. Its applicability depends on crop, soil type and grower practices. Strip-till field tomatoes, sugar beets (Figure 7) and pumpkins (Figure 8) are grown in Ontario on a limited acreage.

Figures 7 and 8. Sugar beets (left) and pumpkins (right) grown in Ontario using strip-tillage in combination with cover crops

Benefits of strip-tillage

There are many benefits to a strip-tillage system. Strip-till provides significant labour, fuel and time savings, while improving fertilizer application options and maintaining soil health over time.

FUEL AND LABOUR

- Strip-tillage reduces fuel use by lowering the number of tractor passes across the field.
- A four-year study in Ontario from 2002-2005 on clay loam soil found strip-tillage reduced fuel consumption per acre by over 50% compared to chisel plowing and by 70% relative to moldboard plowing[2].
- Actual fuel consumption and savings during strip-tillage will depend on the soil type, equipment configuration, strip width, tillage depth, and speed.
- Strip-tillage reduces labour requirements, as separate operations of primary and secondary tillage are combined into one. Late summer or fall strip-till can also shift tillage labour to a less demanding time of year. Additional labour savings may come from reduced need for rock picking.

Figure 9. Some strip-tillage machines, such as this coulter-based unit, come equipped with dry fertilizer delivery systems.

Figure 10. Air carts can also be after-market additions to strip-tillage equipment, as seen in this example.

(2) McLaughlin, N.B., C.F. Drury, W.D. Reynolds, X.M. Yang, Y.X. Li, T.W. Welacky, and G. Stewart. 2008. Energy inputs for conservation and conventional primary tillage implements in a clay loam soil. American Society of Agricultural and Biological Engineers. 51(4):1153-1163. doi: 10.13031/2013.25231

FERTILIZER APPLICATION

- Fertilizer can be placed directly in the strips during the tillage pass, combining fertilizer application and tillage into a single operation (Figures 9 and 10).
- Proper fertilizer placement remains important, just as in other reduced tillage systems:
  - Shallow-banded fertilizer can provide a "starter effect". However, shallow placement increases seed burn risk depending on blends and timing.
  - Deeper banding (e.g., 15 cm (6 in)) provides more seed safety but delays root access and early plant uptake, which is important for corn on low fertility soils.
  - Mixing fertilizer throughout the strip may offer a compromise between shallow and deep banding.
- Risk of phosphorus and nitrogen losses are reduced by placement of fertilizer below the soil surface.
- Applying fertility during strip-tillage may enable fertilizer application equipment to be removed from the planter, reducing planter weight and speeding up the planting process.

SOIL HEALTH AND CONSERVATION

- Ontario research found lower soil bulk density and penetration resistance (a measure of compaction) in-strip after 14 seasons in a clay loam soil relative to both conventional and no-till systems[3].
- Strip-tillage preserves moisture and enhances soil structure relative to conventional tillage, while providing faster seed germination and plant emergence than no-till. In some studies, soils under strip-till management have shown increased soil organic matter levels as compared to conventional tillage and/or no-till[4].
- Strip-tillage reduces erosion risk relative to conventional tillage in many situations (Figure 11).

Fall strip-till on sloping fields can represent an erosion risk, as strips can funnel water during the non-growing season. Shifting to spring strip-till and/or running strips along contours are two strategies that can reduce the risk.

Figure 11. Strip-tillage is a natural fit within a soil health-focused cropping system. It is used to manage residue within the crop row while maintaining cover between rows to reduce overall erosion risk.

GREENHOUSE GASES

- Strip-tillage releases substantially less carbon dioxide (CO_2) when compared to conventional tillage systems, due in part to fewer tillage passes and lower overall fuel usage.
- Ontario research, conducted at Agriculture and Agri-Food Canada's Harrow research station, found that strip-till reduced nitrous oxide (N_2O) emissions relative to conventional till and no-till corn production systems[5].

(3) Shi, X.H., X.M. Yang, C.F. Drury, W.D. Reynolds, N.B. McLaughlin, T.W. Welacky, and X.P. Zhang. 2011. Organic carbon under zone tillage in a clay loam in southwestern Ontario. Soil Science Society of America Journal. 75:1083–1089. doi:10.2136/sssaj2010.0319.

(4) Fernandez, F.G., B.A. Sorensen and M.B. Villamil. 2015. A comparison of soil properties after five years of no-till and strip-till. Agronomy Journal. 107:1339-1346. doi: 10.2134/agronj14.0549.

(5) Drury et al, 2012. Nitrogen source, application time, and tillage effects on soil nitrous oxide emissions and corn grain yields. Soil Science Society of America Journal. 76:1268-1279. doi: 10.2136/sssaj2011.0249.

Strip-tillage within the cropping system

SHANK VS. COULTER MACHINES

Strip-tillage equipment is often classified as shank or coulter type. Both types make use of rolling disks or coulters, which may be wavy or flat. Shank styles also include a tillage shank while coulter types do not. Ontario growers have shared general pros and cons for shank and coulter machines.

PROS AND CONS FOR SHANK AND COULTER MACHINES

TILLAGE TYPE	PRO	CON
Shank	• effective ground penetration under dry summer conditions • some control over fertilizer placement (ability to balance starter effect with crop safety)	• less able to make finely aggregated seedbed with deeper tillage in wetter soil (e.g., spring) • higher horsepower requirement
Coulter	• lower horsepower requirement • flexibility to perform in fine-textured and/or wetter soils • fewer issues with handling or bringing up stones	• poor ground penetration under dry summer conditions • challenges incorporating heavier cover crop stands

There is significant variability in equipment, so the list does not apply universally to all shank or coulter machines. Satisfaction often comes down to the individual machine and operator objectives.

EFFECTS ON SOIL MOISTURE AND TEMPERATURE

Strip-tillage generally increases soil temperature and lowers soil moisture in the strip in the spring relative to no-till. This can enable earlier planting into strip-tilled soil, where conditions are typically similar to conventional tillage. The un-tilled zone remains cooler and wetter, but since it has not been tilled it is better able to support equipment. Residue cover between strips helps to conserve soil moisture during the hot, and sometimes dry, summer months.

Figure 12 shows the difference in soil moisture amongst strip-tilled (on-strip and off-strip), fall-disked and no-till treatments in a trial on loam soil at 5 cm (2 in) depth in the days leading up to corn planting. Note the similarity in soil moisture between the on-strip and fall disk treatments. Figure 13 shows enhanced soil drying on-strip within the strip-till treatment.

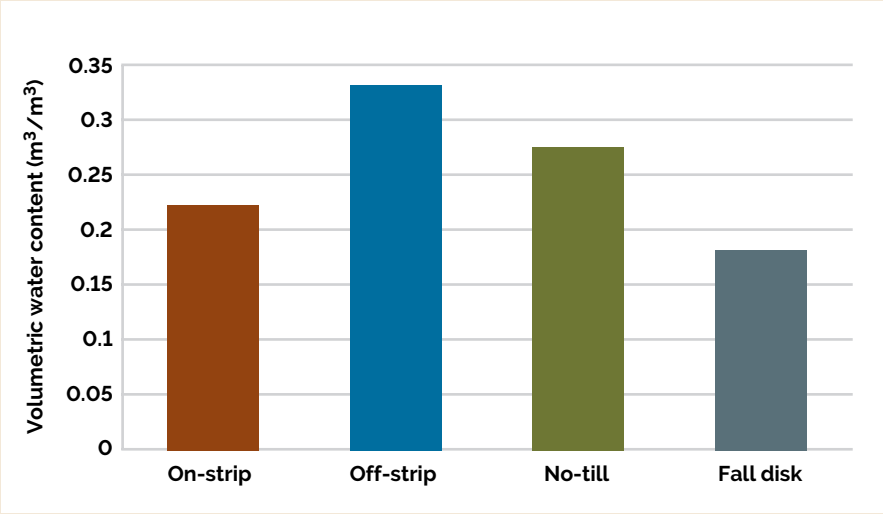

Figure 12. Soil moisture content in a loam soil near Elora, Ontario, at 2-inch depth from May 7-10, 2021. Averaged across two sampling locations. Bars show standard deviation across time points. Source: OMAFRA, unpublished data.

Figure 13. Soil profile view of the berm created by fall strip-tillage at the Elora site from the graph above. Elevated, residue-free soil in the strip-till berm (right side) dries out and warms up more quickly than untilled soil.

CHOOSING BETWEEN FALL AND SPRING TIMING

There are benefits and drawbacks of both fall and spring strip-till. In many cases, the decision is soil type dependent. Ontario growers have found spring strip-till works more reliably on lighter-textured soils (e.g., sandy loams) than heavier-textured soils (e.g., clays and clay loams), where fall strip-till is a better fit. The spring strip-tillage operation usually precedes the planter by no more than 6-12 hours to prevent the seed zone from drying out excessively. Fields with long slopes that are vulnerable to water erosion (e.g., silt loams) may be best suited to spring strip-till.

CONSIDERATIONS FOR SPRING VS. FALL STRIP-TILLAGE	
SPRING STRIP-TILLAGE	**FALL STRIP-TILLAGE**
Best suited to coarse-textured soils	More reliable choice on fine-textured soils
Shorter period of vulnerability to erosion in the strip	More vulnerable to erosion in the strip
Time and labour required during busy spring season; planting must occur very shortly after	Shifts work to late summer or fall, when labour and fertilizer may be more readily available
Fine seedbed may be more difficult to achieve on some soil types	Soil aggregates broken down by freeze-thaw cycles over winter, which assists in providing good seedbed conditions
Enables nitrogen application in-strip	Should not be used for nitrogen fertilization due to high risk of loss
Often, but not always, favours coulter-based strip-till machines	Performed with either a shank or coulter-based strip-till machine

Fall or late summer strip-tillage provides the advantage of completing tillage and fertilizer applications (primarily phosphorus and potassium) well in advance of the busy spring period. It also provides a wider window for tillage in fit soil conditions and time for freeze-thaw cycles to mellow soil chunks ahead of planting (Figure 14). However, spring strip-till enables application of more mobile nutrients, such as nitrogen and sulphur, within the strips closer to the time of planting.

Figure 14. Fall strip-tilled zone (left) compared to spring strip-tilled zone (right) with a shank style strip tiller on a clay loam soil. Fall strip-tillage resulted in a finer, more mellow seedbed.

SINGLE VS. TWO-PASS SYSTEMS

Some farmers will perform two passes of strip-tillage. The first pass is done in the fall and the second in the spring. The spring pass is often very light and coulter only (Figure 15). There is usually a specific reason for the spring pass, such as clearing residue from fields that pond over the winter, or to include some nitrogen or starter fertilizer rather than applying it through a planter. Performing secondary spring strip-tillage may increase yields when fall-only strips perform worse than conventional tillage corn, or where fall strips are very poor (e.g. residue not sufficiently cleared or poor soil uniformity within strip). Where a fall strip provides a well cleared, uniform seedbed in the spring, there is likely little economic benefit for a second spring pass.

Figure 15. Fall strips being "freshened" with a second pass in spring to apply starter fertilizer for corn.

WEEDS

Strip-tillage tends to result in more winter annuals, biennials and perennials – weeds commonly associated with no-till – over time. For example, weeds such as dandelion and burdock may increase. This is particularly true if other crops in rotation are managed with no-till. In some cases, strip-tillage systems may require slightly higher-cost herbicide programs to manage these weed species. Fall herbicide applications are also beneficial to control perennial weeds in strip-tillage systems. Ontario strip-tillers indicate additional weed management is well worth the effort given the benefits from the strip-tillage system.

DIVE DEEPER INTO STRIP-TILLAGE

For more in-depth information on strip-tillage, including common challenges, read *Strip-Tillage in Ontario: Making It Work*. The sequel to this factsheet provides a detailed look at topics such as residue management, fertilizer and manure application, soil sampling, GPS guidance and integrating cover crops within strip-till systems.

For more information

ONTARIO MINISTRY OF AGRICULTURE, FOOD AND RURAL AFFAIRS

Many sources of supplementary information are available. Most can be found online at ontario.ca/omafra or ordered through Service Ontario.

- *Agronomy Guide for Field Crops*, Publication 811
- Soil Erosion – Causes and Effects, OMAFRA factsheet 12-053
- www.fieldcropnews.com

Best Management Practices Series

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