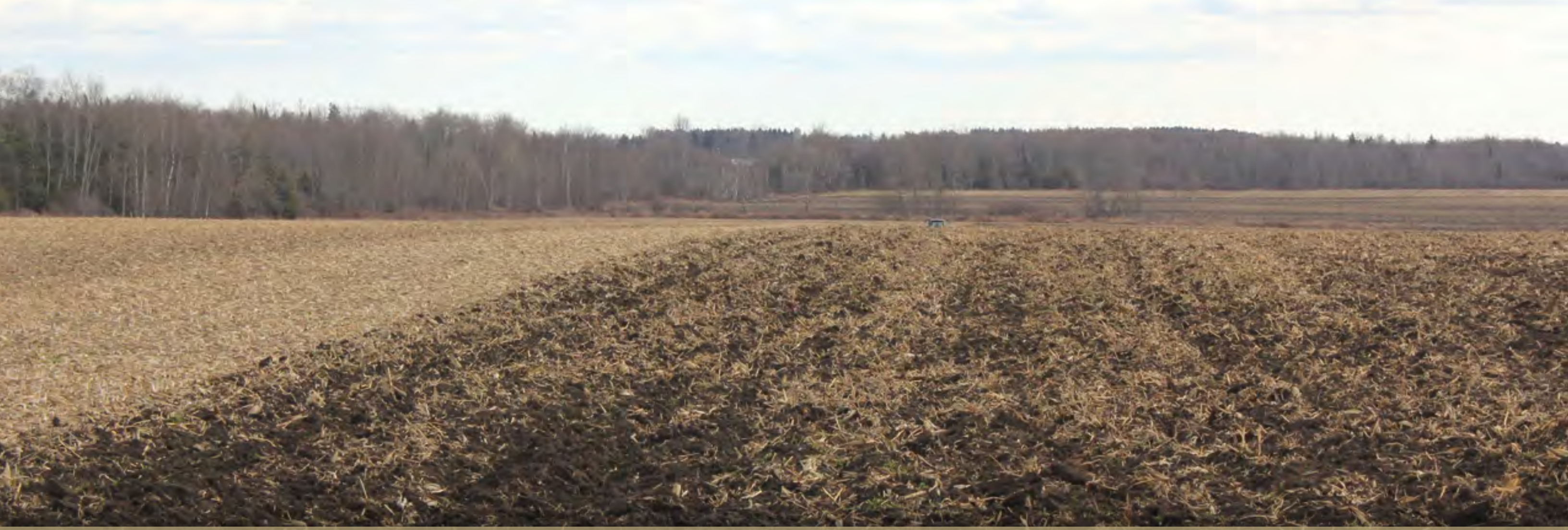


Best Management Practices

MULCH TILLAGE

Over the last 70 years, cropland agriculture has undergone a period of unprecedented agronomic improvements. While yield gains have been remarkable, recently the long-term effects on soil health, structure and fertility have come into focus. A decline in cropland soil health and surface water quality in regions of intensive agriculture are evidence that conventional cropping and tillage systems are not sustainable.

Conservation cropping and tillage systems have been developed and refined over the last 40 years to help keep precious topsoil in place and promote soil health. These systems adjust management, inputs and hardware to grow crops while conserving soil and water – an achievable goal. This factsheet explains mulch tillage systems, which are well-suited for heavier soils, high crop residues like corn, cover crops, plowdowns, and organic amendments.

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.

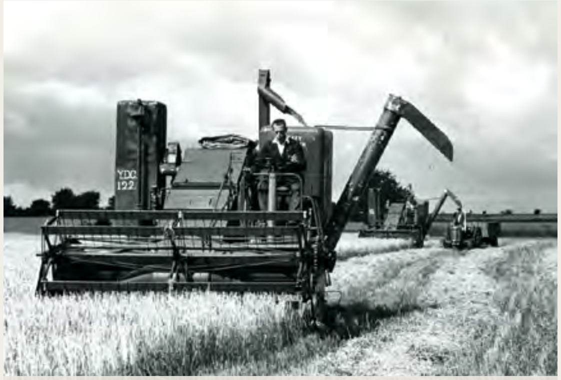
Ontario Federation of Agriculture
Ontario
Canada

Problems with conventional tillage

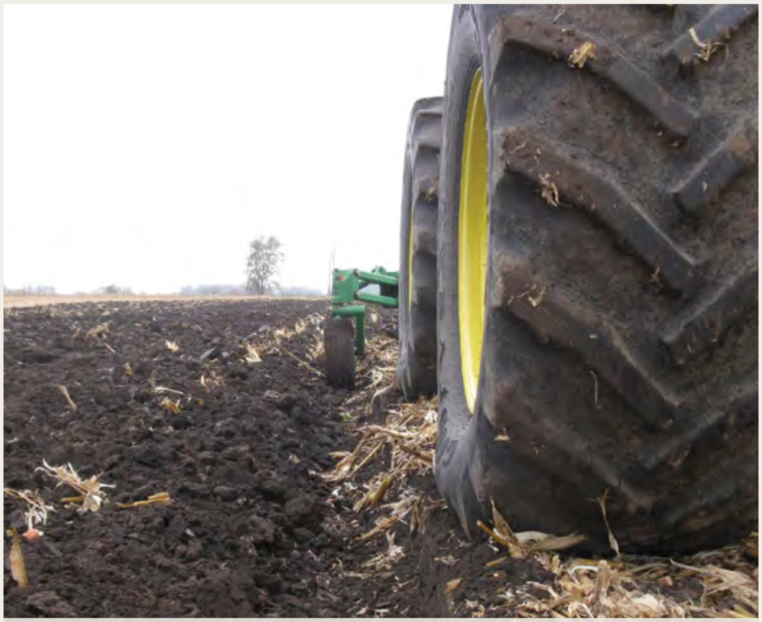
Conventional tillage is any system that attempts to incorporate most of the residue (crop remains), leaving less than 30% of the soil surface covered with residue after planting. Usually, the plow is used along with a variety of other tillage tools in a conventional system.

Conventional tillage and other production practices that boosted productivity have compromised soil quality in several ways.

- While soil productivity improved for a time, it levelled out as inherent fertility and tilth (physical condition) were depleted.
- Soils were worked to bury trash, incorporate inputs and create fine seedbeds, which worked reasonably well until the reservoir of organic matter from past forage crops and pasture was used up.
- Lower soil organic matter levels translated into poorer soil structure, increased compaction and surface crusting, and reduced water-holding capacity.
- Lower quality soil conditions led to increased rates of wind, water and tillage erosion.
- Soil materials and the inputs (fertilizer, pesticides) they carried contributed to the pollution of adjacent surface waters.



In the mid-20th century, improvements in crop production systems led to unprecedented increases in crop yield and crop quality – an era often referred to as the Green Revolution.



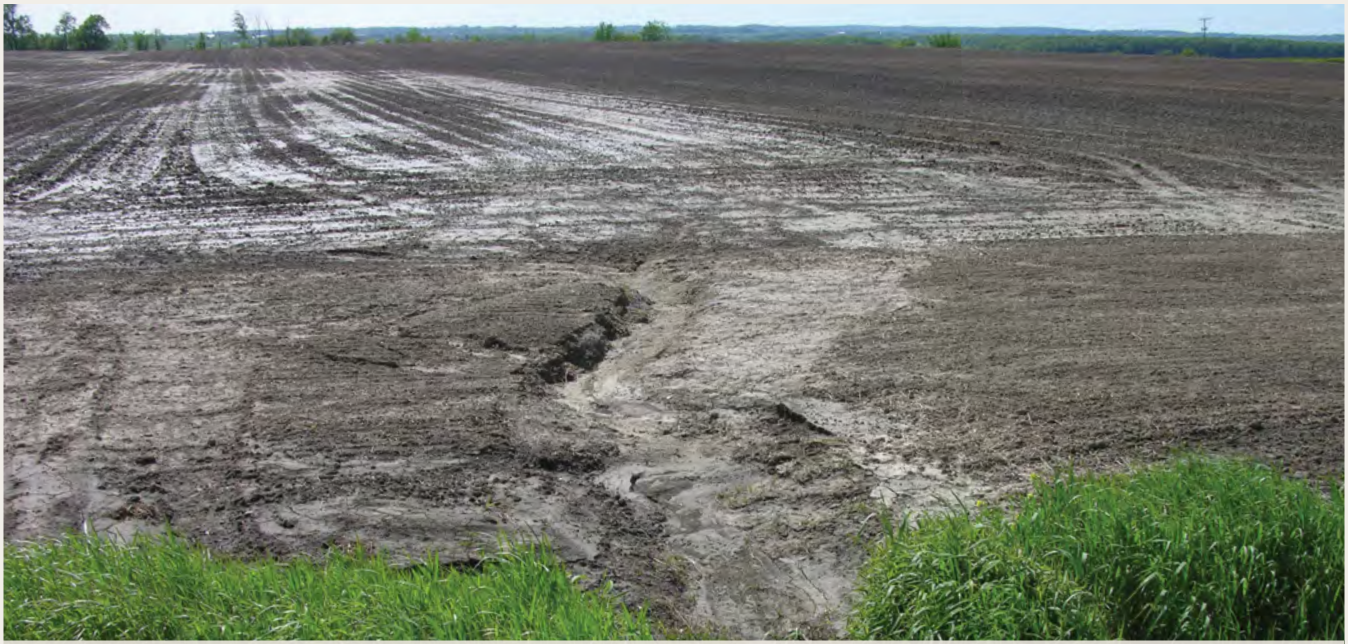
Research indicates that most cropland soils managed with a conventional tillage system have lost at least half of the original organic matter from the topsoil.

Farm enterprise specialization and the intensification of production led to a reduction in the number of acres managed with forage-based crop rotations. However, tillage practices didn't change much. As a result, soil organic matter became depleted, soil structure was degraded, and by the 1970s, erosion was a common sight on Ontario cropland.

TILLAGE EROSION – Severe erosion of upper slopes may be caused by a process called tillage erosion. When soil is worked by conventional tillage, the action of the tillage implement lifts soil and moves it forward. Gravity pulls the soil downhill when it is disturbed. The net result is that soil moves down the slope with tillage.

Ontario research indicates that over 100 tonnes per hectare (1,487 bu/acre) of soil is lost from upper slopes each year. Additional erosion by wind and water can increase the rate to over 150 tonnes per hectare (2,230 bu/acre). An acceptable level would be 4 tonnes per hectare (60 bu/acre).

STRUCTURAL DEGRADATION – In conventional tillage systems, with minimal inputs of organic amendments, every pass breaks clods, exposes soil organic matter to decomposition by soil microbes, and weakens structural integrity and resilience. In extreme cases, soil structure is so weakened that it impedes seed germination and crop growth.



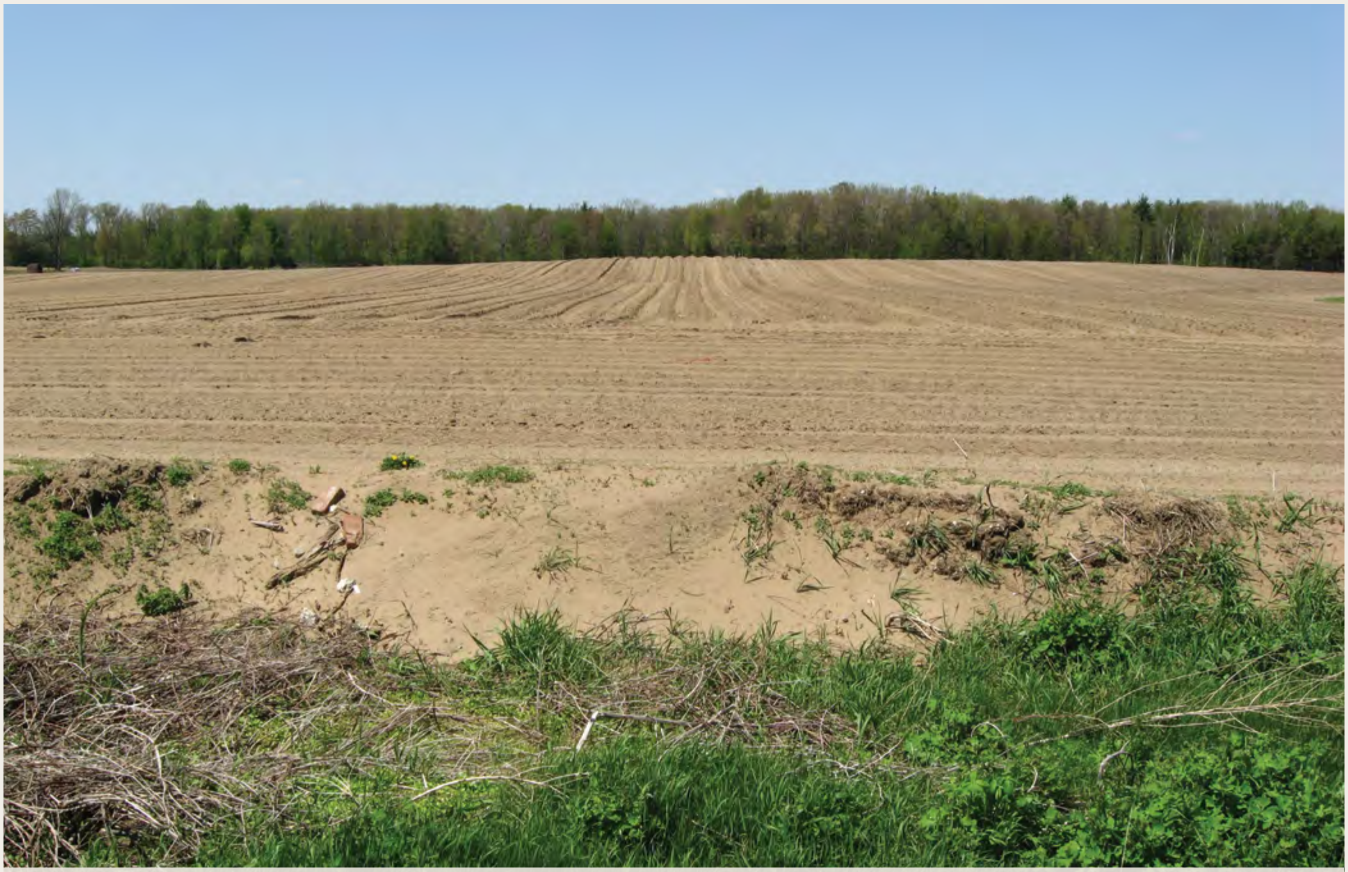
SEDIMENTATION AND RUNOFF – Detached soils can be deposited in depressional or level slope conditions downslope. Where concentrated flow persists, eroded soil (sediments) will be carried off-site to surface water bodies such as rivers and lakes. Sediment loading harms surface water quality. In time, nutrients attached to soil sediment will become available to aquatic plants, which promotes algae growth. Sedimentation in watercourses can also impede water flow and navigation by watercraft.

SMEARING AND COMPACTION – The weight and shearing action of conventional tillage implements on moist to wet soil can cause smearing of soil at the depth of tillage. Years of tilling at the same depth and similar moisture conditions form layers of compacted, platy structure in the soil – also known as plow pans.

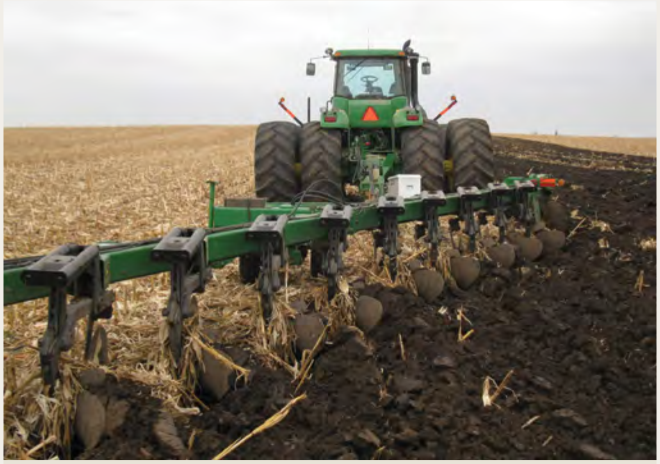
SOIL LOSS – Conventional tillage with the moldboard plow creates the highest risk for soil erosion. Soil loss varies with slope, the amount of runoff, soil organic matter levels and the amount of residue cover. Soil plowed in the fall, left with little or no residue, loses more soil to erosion than soil managed with any other type of tillage system.

On clean-tilled soils, raindrop impact dislodges soil particles, and flowing water from rain events and snowmelt collects sediments and moves them into adjacent surface waters. Unchecked, this process will result in the complete loss of productive soil.

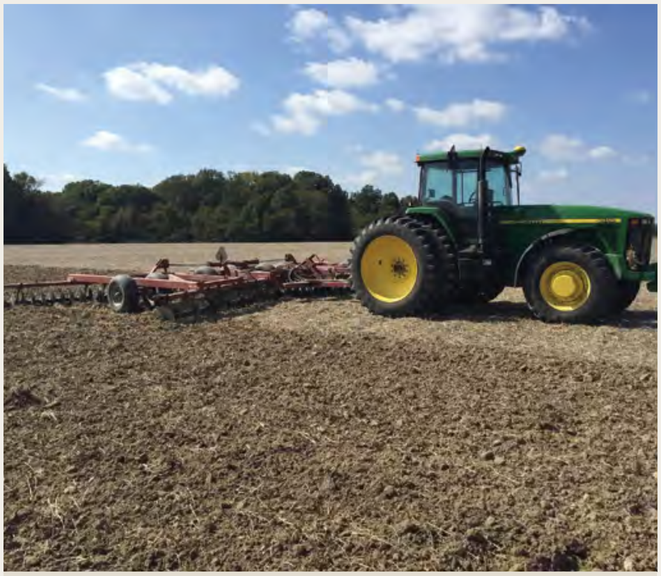
CARBON LOSS – Fine seedbed structure created by tillage enhances soil microbes' ability to decompose organic compounds found in the soil humus. Years of conventional tillage and no additions of organic amendments will deplete organic carbon levels as well.



WIND EROSION – Excessively tilled sandy soils are the most prone to wind erosion. Soils with low organic matter, poor aggregation and structure, and low moisture conditions are especially vulnerable to wind erosion if left bare.



BURIED TRASH – Moldboard plows can bury a lot of corn residue. Deep plowing can bury it so completely that the residue can form a distinct layer in the soil below the seedbed. This layer can become problematic for the following crop – limiting root growth, affecting water movement through the soil, forming an anaerobic layer, reducing the rate of residue decomposition in the soil, and interfering with the availability of nitrogen to the growing crop.



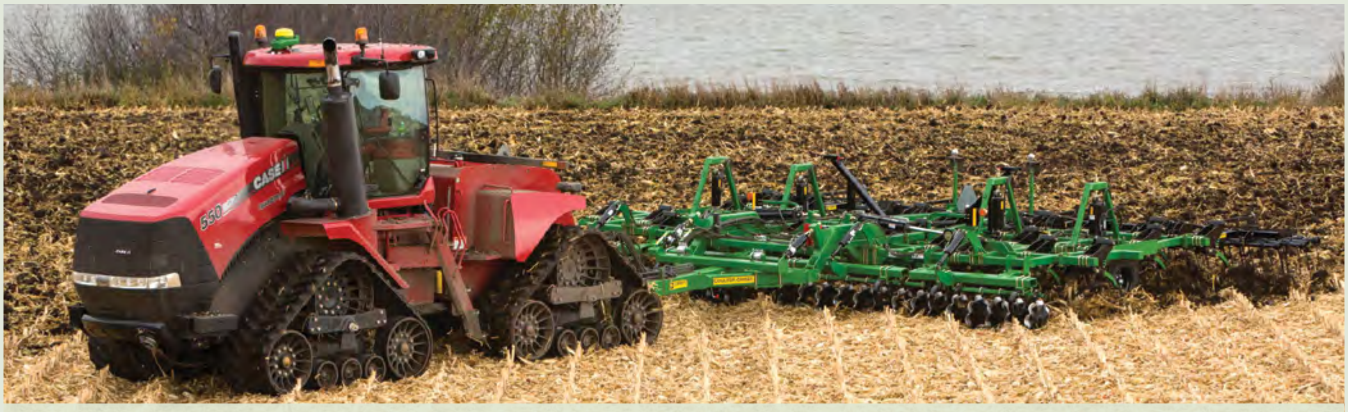
Conventional tillage leaves no residue on the surface – increasing the risk of erosion and runoff (with phosphorus attached). Using implements such as chisel plows, disc-chisel plows and discs, mulch tillage does not work the soil as finely as conventional tillage, and buries less residue.

How mulch tillage works

In mulch tillage systems, more than 30% of the soil surface is left covered with residue after planting. Chisel plows, offset discs or modified moldboard plows are the common implements. Other terms that you may hear to describe this system are *reduced tillage, minimum till* or *conservation tillage*.

Mulch tillage systems can work under field conditions that do not work well for no-till. Mulch tillage is better suited to heavier soils, high crop residues, cover crops, plowdowns, and additions of organic amendments such as manure and compost. It can also be used as a way of transitioning to no-till.

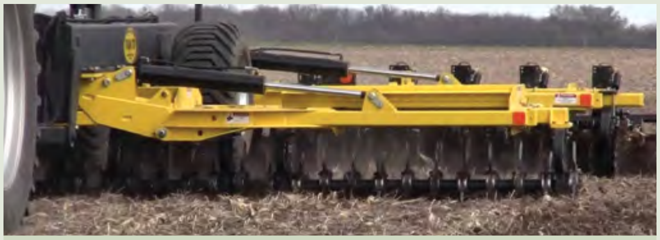
Mulch tillage can be achieved with many different tillage tools that leave varying amounts of residue.



CHISEL PLOWS – The coulter-chisel plow (or disc-chisel plow) is a commonly used type of chisel plow. It combines a gang of discs or coulters in front of the chisel teeth to work in all residue conditions. A variety of teeth or sweeps are attached to the shanks. Chisel points are straight and move through the soil doing very little mixing. They can be used to open up shallow soil compaction. Twisted shovels bring the soil up and provide some mixing of soil and residue. Sweeps cut through the soil horizontally, lifting the soil and shattering it.

A combination of sweeps and twisted shovels can be used to disturb more soil and to leave more or less residue on the surface. The cutting action of the coulters/discs is necessary for handling corn stalks. This makes it easier for secondary tillage. After one pass, 30–75% of the residue is left.

DISCS – Discs are concave, circular steel disks arranged in rows, usually on an angle, that cut and pitch the soil in a way somewhat similar to a moldboard plow. Discs are used for both primary and secondary tillage. Residue is mixed into the soil about three-quarters of the depth of tillage.



ROTARY TILL IMPLEMENTS – A rotary till implement (e.g., Aerway) is a primary/secondary mulch tillage implement for lighter soils. It is a single tool bar equipped with non-powered rotating knives. The frame is heavy enough that extra weights can be attached.

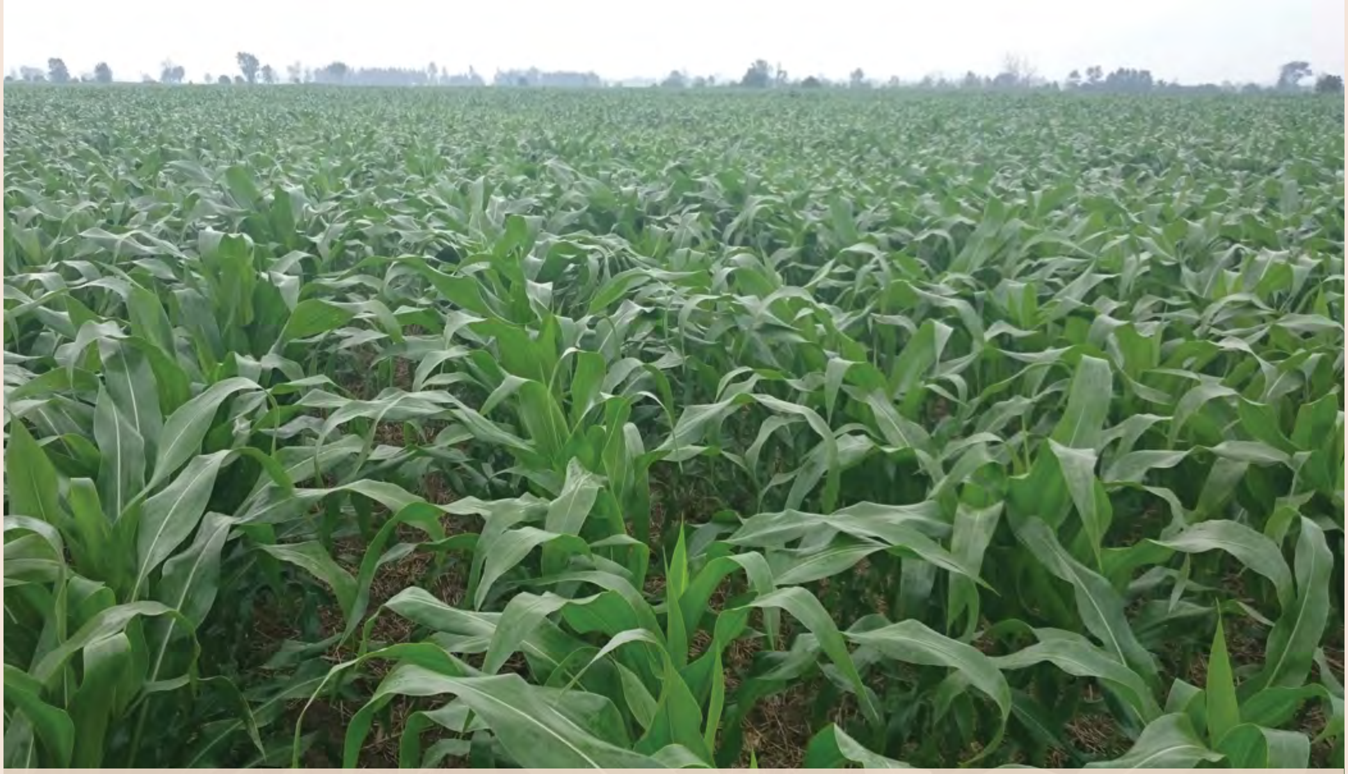
This implement can be used for one-pass tillage, although it is more common to make two passes. It will leave considerable residue on the soil, while leaving the surface relatively level.

Benefits of mulch tillage

Mulch tillage systems are sustainable: they can produce similar yields using fewer inputs than conventional systems, with minimal environmental impact.

LESS DISTURBANCE – **In mulch tillage systems, soils are lifted but not completely flipped over. Less disturbance means less structural degradation and less biological oxidation (loss) of organic matter. With fewer disturbances, soil life diversifies – favouring such beneficials as VAM (vesicular arbuscular mycorrhizae).**

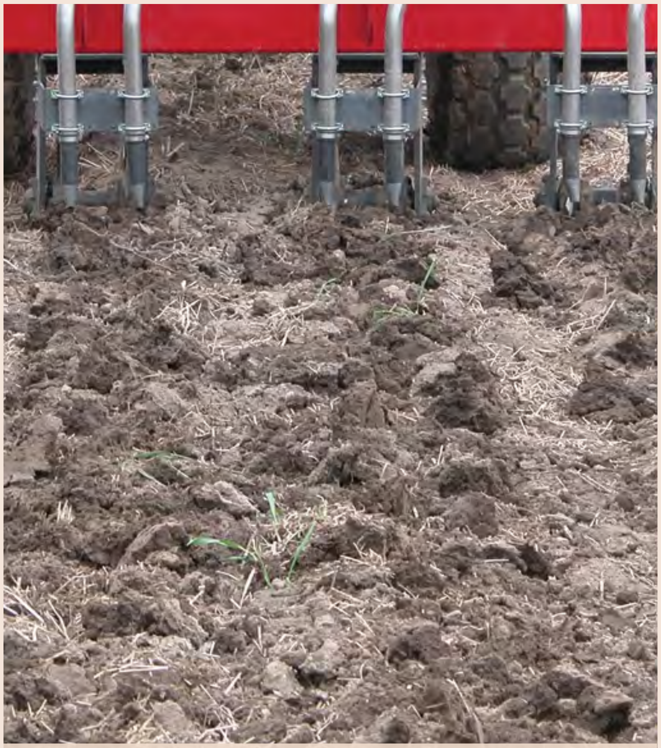
RESIDUE COVER – **Uniformly distributed residue shields the soil surface from rainfall impact, and this reduces soil particle detachment and loss.**



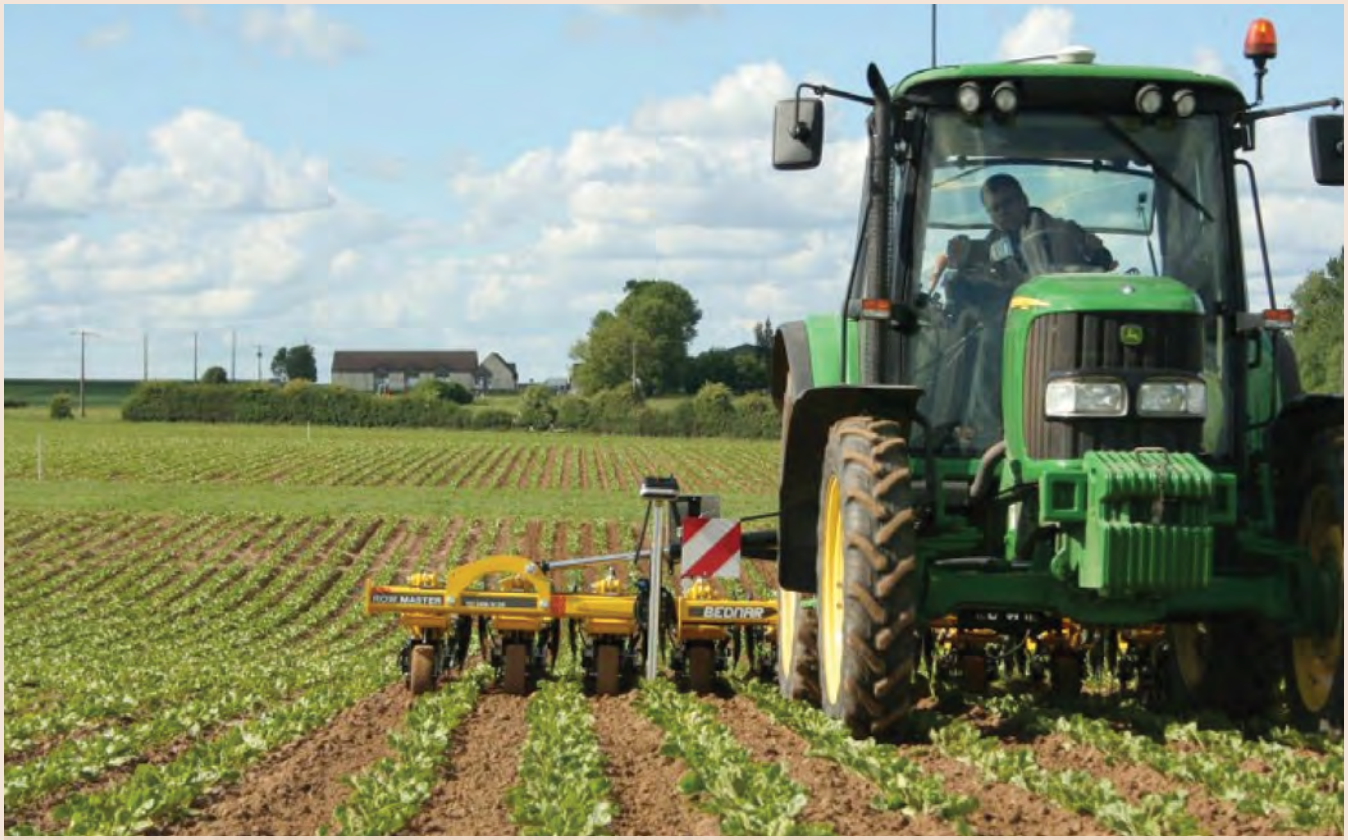
COMPARABLE YIELDS – **Most field trials between tillage systems show that yields are similar with conventional, mulch and no-till systems.**

INCREASED FLEXIBILITY – Mulch tillage systems are more flexible than no-till systems. Nutrients (e.g., liquid-injected manure) can be applied during the growing season.

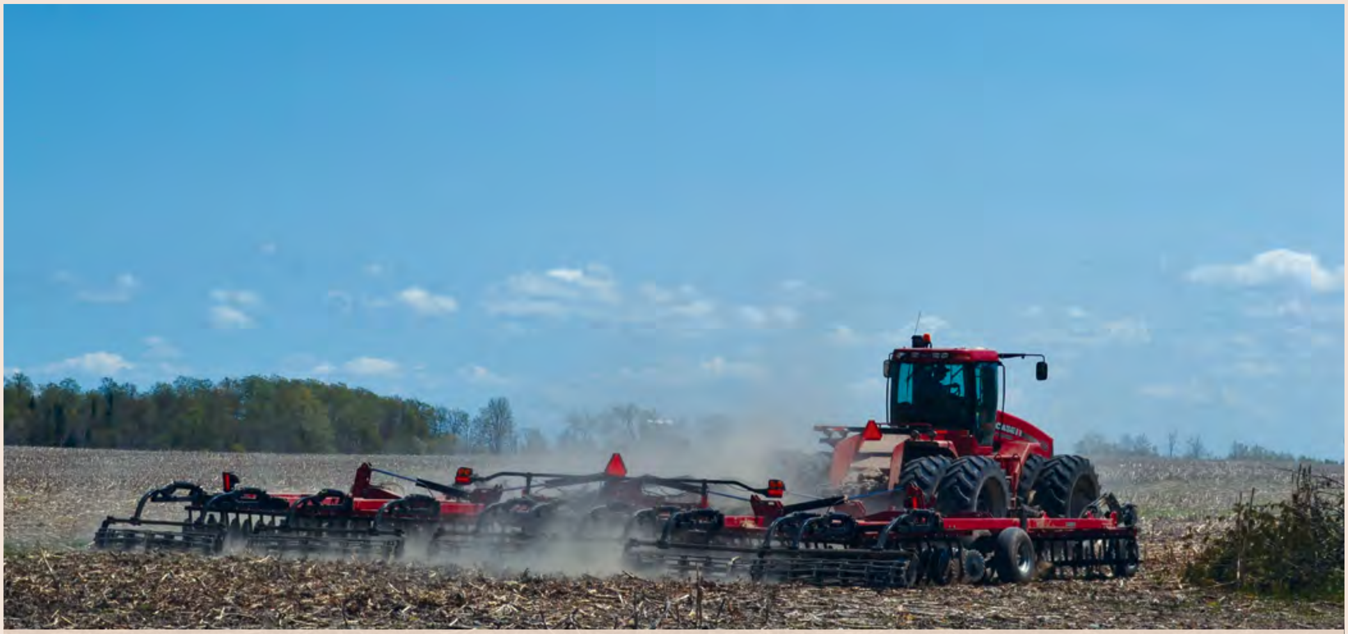
REDUCED RUNOFF – Crop residue left on the surface after mulch tillage creates small dams that slow the rate of runoff, allowing more time for water to infiltrate into the soil. A slower rate and reduced volume of runoff means less soil removed from the field.



CARBON MANAGEMENT – Fewer passes with mulch tillage means lower fuel requirements and lower rates of carbon emissions from cropland.



DIVERSE PEST CONTROL METHODS – Unlike no-till systems, which are mostly limited to pesticide use, mulch tillage can use primary tillage and cultivation to control weeds and pest-friendly habitats.



REDUCED COSTS – Seedbeds are prepared with fewer passes than with conventional systems. This translates into less time, less fuel, fewer implements and less wear on the implements – in other words, lower costs. For example, on 500 acres, the time savings can be as much as 225 hours per year. That's almost four 60-hour weeks. Further, it will save an average 3.5 gallons of fuel an acre or 1,750 gallons on a 500-acre farm. Fewer trips save an estimated $5 per acre on machinery wear and maintenance costs – a $2,500 savings on a 500-acre farm.

Challenges with mulch tillage

- Adjust planting and application equipment to handle higher residue.
- Move residue off the planting row if residue cover is high. This will improve seedbed moisture and temperature conditions for germinating seeds.
- Rotate crops to reduce pest pressures as some residue is left at or near the soil surface.
- Manage weeds more carefully. Less cultivation means more scouting and fewer tools.
- Use starter fertilizer. Mulch-tilled soils can be cooler than and not as mixed as conventionally tilled soils.
- Monitor soils for compaction and smearing. Discs can smear soils if moisture conditions are not ideal for tillage.
- Monitor effectiveness of equipment modifications and cultural practices.

Managing weeds in a mulch tillage system requires a planned and systematic approach. Prior to implementing a conservation tillage system, growers should identify the specific weed species and their densities present in the field(s), and determine the weeds' growth habit (annual or perennial). It is also important to evaluate whether the weeds have developed resistance to herbicides based on past experiences in a specific field and surrounding areas.

Mulch tillage will leave seedbeds cooler and wetter. This may increase the risk of certain diseases such as phytopthora.

When changing tillage systems from conventional to mulch, cropland soils can be compacted. Mulch tillage will not help this condition much, as soils aren't worked as thoroughly. In time, soil structure will improve, but yield losses may be noticed in the first few years. Fitting a range of cover crops into the rotation will help improve soil quality.

Mulch tillage: making it work

SYSTEMS APPROACH

✓ Adopt a systems approach.

A systems approach is required to make a change in tillage work. Adjustments need to be made to planting equipment, weed control practices, and the timing of operations. The most resilient systems are those where the implications of improvements to one component were anticipated and the necessary adjustments to other components were made at about the same time.

SOIL MANAGEMENT

✓ Assess soil health and surface water conditions. Mulch tillage won't solve severe soil health issues in the short term.

✓ Improve drainage. Ponded areas and excessive moisture will impede the success of any conservation tillage system. You can't correct poorly timed tillage operations with more tillage.

✓ Improve seedbed conditions. Use applications of composts, plowdowns, manure or cover crops to improve seedbed tilth.

✓ Test soils and follow recommendations for soil fertility.

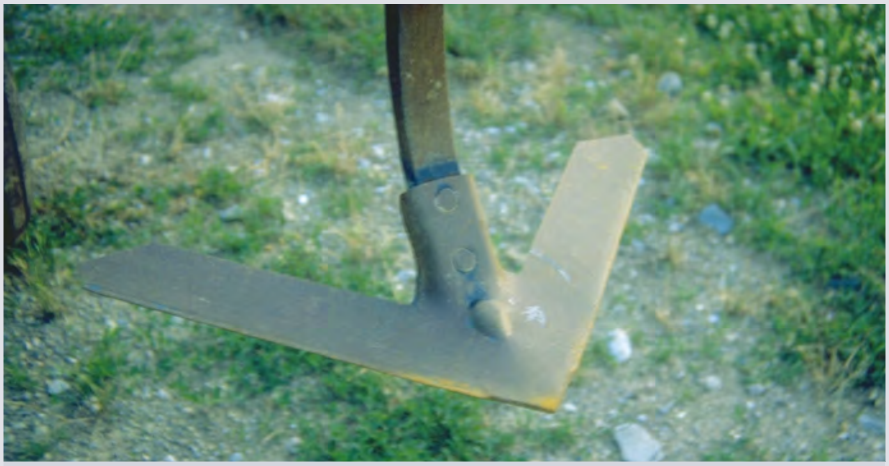
TILLAGE IMPLEMENTS

Different tillage tools leave varying amounts of residue.

Chisel Plows

Chisel plows are used for primary tillage. There are several types available.

The coulter-chisel plow is the most common in southern Ontario. It combines a gang of discs or coulters in front of the chisel teeth to work in all residue conditions. The cutting action of the coulters/discs is necessary for handling corn stalks. This makes it easier for secondary tillage. After one pass, 30–75% of the residue is left.

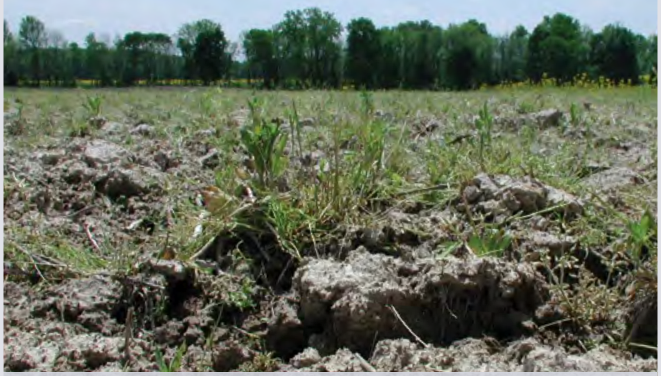


Chisel plows use chisels, twisted shovels or sweeps to lift and shatter soil without flipping over the crop residue on the surface.

Discs

Discs are used for both primary and secondary tillage. Residue is mixed into the soil about three-quarters of the depth of tillage. Discs will leave 30–70% of residue after one pass while they break up the residue and loosen the soil surface.

Use of discs in wet soil conditions can lead to compaction at the tillage depth. This is caused by pressure exerted by the curvature of the blade. This problem can be minimized by varying the depth of tillage every year, or by alternating primary tillage tools every few years and tilling when the soil is fit.



Discs can compact moist to wet soils. Reduce the risk with careful timing and by varying the depth of tillage.

Rotary Till

A rotary till implement (e.g., Aerway) is a primary/secondary mulch tillage implement for lighter soils. Its success has been limited on heavier soils due to problems getting adequate penetration. It is a single tool bar equipped with non-powered rotating knives. The frame is heavy enough that extra weights can be attached.

This implement can be used for one pass tillage, although it is more common to make two passes. It will leave considerable residue on the soil, while leaving the surface relatively level.

Implement Tips

✓ Keep secondary tillage to a minimum to conserve residue. It should be sufficient to mix in fertilizers, work in pre-plant herbicides and level the surface.

✓ Minimize plugging problems from heavy residue, like corn stalks. Field cultivators may need to have a few tines removed and others re-spaced for better residue flow. An overall spacing of 13–15 cm (5–6 in.) between tines should give the best compromise between residue flow and a level seedbed.

✓ Consider trading in the S-tine cultivator for a high-clearance C-shank cultivator. C-shank cultivator frames are stretched and raised to make residue flow easier.

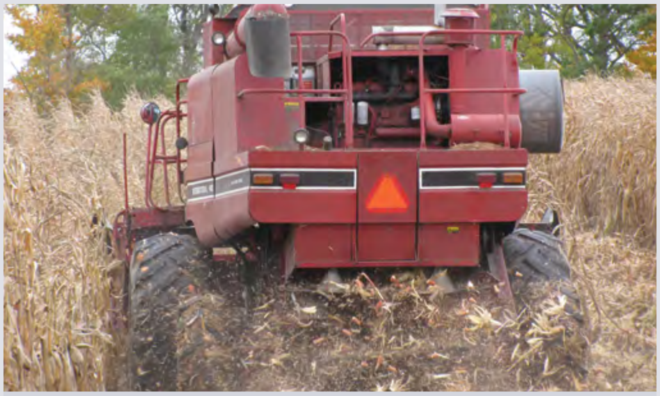
Plowdowns will help to get your soil in shape for mulch tillage.

RESIDUE MANAGEMENT AND PLANTING

Residue management is the management of residues from the previous crop to provide soil cover after harvest and until the development of the canopy of the next crop.

✓ Spread residue evenly. To get good erosion control and, more importantly, to make tillage and planting easier, residue must be spread evenly behind the combine rather than windrowed. An even-spread pattern protects more soil and reduces plugging problems with tillage and planting equipment.

✓ For small grains, set the cutting head on harvest equipment as high as possible without sacrificing yield. That way, more of the stalk is left in place and less passes through the combine.

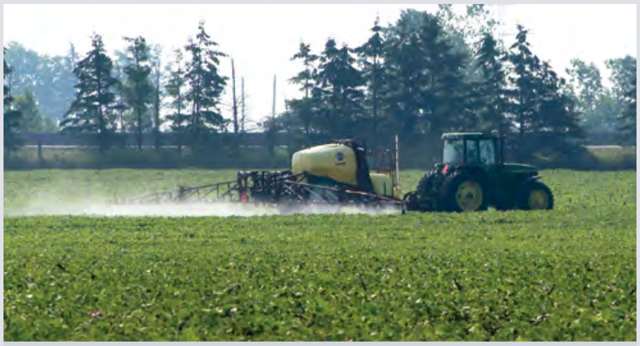


Spread residue evenly behind the combine to eliminate windrows and improve ground coverage to protect the soil.

✓ Modify planting equipment with coulters or trash whippers to move crop residue out of the row area. This helps eliminate any toxic effects and clears the row, so soils warm up.

In conservation tillage systems, residue from the previous crop is left on the surface or only partially buried. The material acts like a mulch to protect the soil, and as it breaks down it adds organic matter to the soil. Here, an even stand of soybeans emerges through the protective mulch effect of wheat residue.

WEED CONTROL



Avoid rescue treatments. Knowing what weeds to expect and using herbicides to control them will help eliminate extra passes over the field to catch "escapes".

The type of control method to use depends on the type of conservation tillage system. More options are generally available for systems where there is some soil disturbance.

Chemical approaches are based on timing of herbicide application and include burndown, soil residual and post-emergence treatments.

- ✓ Apply the principles of Integrated Weed Management for effective, long-lasting control and minimal environmental impact.
- ✓ Scout fields for weed problems carefully and regularly. Identify weed problems early.
- ✓ Keep records for monitoring and scouting. Note weeds scouted and season.
- ✓ Keep accurate records for treatments to help improve treatment efficacy.
- ✓ Consider the economic threshold of control. Make sure the benefit outweighs the full cost of control.
- ✓ Keep in mind that weeds appearing late in the season do not reduce yields as much.
- ✓ Rotate the pesticide family to stay ahead of changes in the weed population.
- ✓ Band herbicide over the row to increase efficacy and efficiency.
- ✓ Use tillage to control weeds in conservation tillage systems. For maximum weed control in conservation tillage systems, one operation (e.g., soil-saver – disc-chisel plow) is performed in early fall or early spring, and the second is completed as late as possible (immediately before planting).
- ✓ Consider row crop cultivation for a good complement to chemical weed control. For greater effectiveness, the second operation should be delayed until the soil warms and the initial flush of germinating weed seeds has emerged. Cultivation can allow for reduced herbicide rates, especially when the herbicide is banded.
- ✓ Be aware that two or more passes with the cultivator may be necessary.

INSECT AND DISEASE CONTROL

Adjust planting equipment so that crop residue is moved out of rows at time of planting. Clear rows reduce pest pressures and help young crops grow without interference from the previous crop's residue.

Insects and other pest numbers may increase if there are a lot of weeds in the field. Weeds can act as a food source or an egg-laying location for pests.

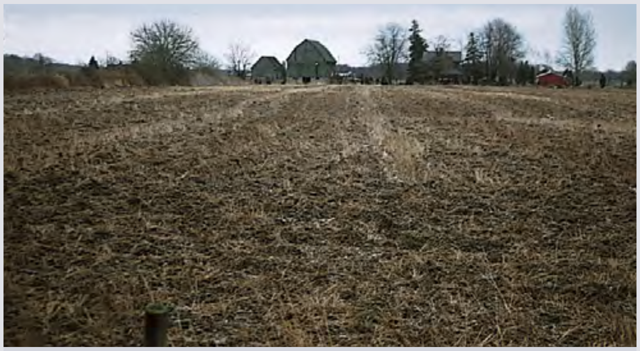
- ✓ Use Integrated Pest Management practices.
- ✓ Use crop rotations to break the disease cycle.
- ✓ Select hybrids or varieties for early growth and vigour where soils tend to be cooler. Choose disease-resistant varieties and be sure to use seed treatments.
- ✓ Modify planting equipment to move residue away from the row area so young seedlings have a good chance to get established without pressure from insects and slugs.
- ✓ Change the family of your insecticide each year. Insects can develop resistance to specific insecticides after repeated use.

COVER CROPS AND MULCH TILLAGE SYSTEMS

In field cropping systems, there is a synergistic effect from using cover crops and reduced tillage/residue management systems. Use of cover crops in mulch-tillage systems has numerous benefits:

- added cover
- soil building
- nitrogen additions – trapping or provision
- weed control
- breaking pest cycles

Winter cover crops can provide much-needed additional cover when residue cover is insufficient for erosion control goals.



Make sure that all vegetation is dead at planting time.

For more information

ONTARIO MINISTRY OF AGRICULTURE, FOOD AND RURAL AFFAIRS

Many sources of supplementary information are available.

Below are some suggestions to get you started. Most can be found online at **ontario.ca/omafra** or ordered through ServiceOntario.

- *Agronomy Guide for Field Crops,* Publication 811
- *Cover Crops: Adaptation and Use of Cover Crops* www.omafra.gov.on.ca/english/crops/facts/cover_crops01/cover.htm
- *Soil Fertility Handbook,* Publication 611

Best Management Practices Series

- *Buffer Strips*
- *Controlling Soil Erosion on the Farm*
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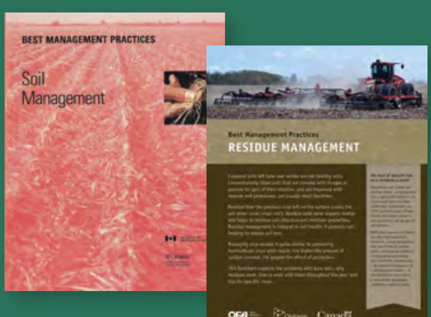
Environmental Farm Plan (4th ed.) and EFP Infosheets

- #15, *Soil Management*
- #18, *Horticultural Production*
- #19, *Field Crop Management*



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