



Best Management Practices

WINTER COVER CROPS

Cropland soil should be covered year round. Bare soils are at risk of erosion by water and wind. There are three main approaches to keeping them covered – especially during the critical period starting at post-harvest of the primary crop until the emergence of the next crop the following spring:

- crop rotations that include forages or pasture can cover soils year-round (see BMPs for Soil Health Factsheets – *Crop Rotations and Perennial Systems*)
- managing the residue from the primary crop to provide cover throughout winter (see BMPs for Soil Health Factsheets – *Residue Management, No-Till, and Mulch Tillage*)
- post-harvest (winter) cover crops.

This factsheet describes some of the benefits, challenges, types and opportunities for growing cover crops in post-harvest conditions in Ontario.

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.

Problems associated with bare soils after harvest



The top few centimetres of bare soils can warm up and remain saturated during winter thaws, making them highly prone to erosion during subsequent storm events.



Erosion researchers estimate that 80% of soil erosion on Ontario cropland takes place during spring and fall rainstorm events.

During much of the growing season, most crop canopies do a reasonable job of protecting the soil surface.

In winter, much of the cropland in Ontario is covered in snow. But snow cover alone is not the answer. Snow is too unpredictable and variable to be a good protector of soil. Snow depth is subject to thaws, storms and runoff.

After harvest or before crops emerge in the spring, bare soils are at risk of wind and water erosion. Eroded soils make poor growing media for commercial crops: tilth is poor and the soil tends to puddle and crust when saturated with rain or snowmelt water. Eroded soils have shallow or missing A horizons (surface horizons) – basically a much thinner layer of the most productive soil because it has been moved by erosion.

In addition, sediment, organic matter and crop inputs that are in runoff from eroded cropland impair the water quality in adjacent creeks, ditches and streams.



WATER EROSION – Bare soils with smooth surfaces and no vegetative cover are prone to detachment and transport of soil particles by water.



WIND EROSION – Large expanses of clean-tilled fields with erodible soil material are prone to severe erosion rates by wind as the soil surface dries out in the spring.



SEDIMENT AND NUTRIENTS IN RUNOFF –

Storm and thaw events in late winter and early spring can lead to large volumes of water accumulating on cropland surfaces. Spring runoff water contains sediments, organic matter and crop nutrients, and can pond and flow into adjacent ditches and streams. This is a key farmland source of phosphates in Ontario surface waters.



NITRATE LEACHING – Nitrate-nitrogen released from crop residues, soil organic matter, fall-applied manure or fertilizer is at the greatest risk of leaching after the growing season. Nitrates can leach through the soil profile and contaminate groundwater sources. Once nitrates are in the water, high nitrate levels can lead to illness or death in livestock and humans (blue baby syndrome).



SEEDBED CONDITION – Bare, finely worked seedbeds are prone to ponding, puddling and crusting – making seedbed preparation challenging later in the spring.



GREENHOUSE GAS EMISSIONS – When crops are not growing, the nitrogen cycle is still at work. Organic forms of nitrogen are transformed into more available forms and these forms are at risk of being lost from the soil. One source of loss is the conversion (denitrification) of nitrates to nitrogen gas (N_2) or partial denitrification to nitrous oxide (N_2O). Of all of the greenhouse gas emissions from agricultural sources, nitrous oxide has the greatest potential to affect climate change.



WEED PRESSURE – Bare field conditions are ideal for weeds to become established and for problem weeds like glyphosate-resistant Canada Fleabane to flourish. Soils covered by winter cover crops reduce weed pressure.

Types of winter cover crops

Generally, post-harvest cover crops are sown following the harvest of the primary commercial crop in summer or fall of the cropping year, and provide effective cover over winter until seedbed preparation or emergence of the next primary crop.

There are exceptions:

- winter cereals
- forage legumes



Spring cereals such as oats and barley can be sown as late as late summer to provide live cover until freeze-up kills them. After that, the crop residue provides a mulch-like cover into the following spring.



Cover crop radish can be planted in late summer to scavenge nutrients, break pest cycles, and reduce soil density. Radishes will die over winter and leave very little residue.

Mix cover crop radish with cereal grains like oats or rye for a cover crop that builds soil structure and retains some residue cover over winter.



Cereals that survive winter and are harvested the following summer – such as winter rye and winter wheat – serve as winter cover crops that may be harvested.



Forage legumes such as clovers or alfalfa can be established in post-harvest conditions and provide cover in fall, winter and early spring. They can then be harvested, grazed and/or plowed-down as green manure that year or the year following for maximum soil health and fertility benefits.

Benefits of winter cover crops



EROSION CONTROL – Cereal rye is a fast-growing winter cereal that produces an immense amount of biomass (3,000–4,000 kg/ha of dry matter if allowed to grow in the spring). These characteristics make this cover crop ideally suited to covering cropland and protecting it from wind and water erosion after crop harvest and through winter.



INCREASED INFILTRATION – Soils with high infiltration rates store more water for the growing season and reduce cropland runoff rates. Soil compaction reduces infiltration. Fast-growing, deep-rooting post-harvest cover crops – such as cover crop radish – have taproots that will create macropores in the soil. Over time, deep-rooted cover crops can penetrate plowpans or dense layers in the soil, improving water movement through the soil.

CLEANER RUNOFF – Winter cereals function like a buffer strip whether the cereal is a crop or a cover crop. The cereal roots hold the soil while the top growth acts as a living filter to reduce soil particles in cropland runoff. The runoff water is cleaner from covered soil.



SEEDBED TILTH – Red clover, with its N-fixing ability and dense root biomass, adds nutrients and organic matter to the seedbed. This feeds soil life and improves soil aggregation.



REDUCE GHG EMISSIONS – Brassica cover crops like turnips or kale can grow in cooler and wetter conditions typical of Ontario fall conditions. These crops can trap soil nitrates and help to reduce nitrous oxide (N₂O) emissions.



TRAPPING NUTRIENTS – Grasses such as cereal rye and brassicas such as radish are heavy nitrogen feeders. They will take up most of the plant-available nitrogen left in a soil in the fall. Good management is needed with winter cereals like rye to ensure that the nitrogen is readily available at the time the next crop needs it.



SEQUESTERING NUTRIENTS – Legumes such as peas fix nitrogen from the atmosphere, scavenge available nitrogen throughout the root zone, and contribute to organic nitrogen levels in the soil as the crop decomposes.



HIGHER YIELDS – Legume cover crops can increase yields of corn by improving tilth, fixing nitrogen, making phosphorus more available, and feeding soil life.



WEED CONTROL – A well-established cover crop will help to suppress weeds regardless of cover crop species. Some cover crops like cereal rye also have allelopathic properties and are more effective at weed suppression.



INCREASED SOIL BIODIVERSITY – One of the many benefits of using post-harvest multi-mix cover crops is the habitat provided to improve the diversity of soil life.



DISEASE PREVENTION – Cover crop mustard for disease suppression is often grown in early spring or fall. These flowering plants also provide some support for pollinators.

Challenges with winter cover crops

Establishment and growth of cover crop

Wet conditions, harvest date of the previous crop, and manure application can all delay planting. Most cover crops need to be planted by the middle of September to achieve reasonable growth and ensure effectiveness for erosion control. Winter cereals such as rye or wheat can be planted later into October. Late planting into cooling soils means slower establishment and growth.

Dry soils in late summer or early fall can interfere with establishment. The risk of waiting for rain in the fall is that you might get too much, then have to wait until it dries enough to plant.

Establishment of main crop

Living mulch or heavy residue cover from winter-killed cover crops can interfere with seedbed preparation and seeding or transplanting. Living cover crops may dry soils out or heavy residue cover may leave soils cold and wet.

Growth pattern

Cover crops such as post-harvest radish produce large leafy biomass to cover the soil and outcompete weeds, while the enlarged roots in the soil help break up compaction and increase aeration and water infiltration. They may be problematic in the spring for no-till growers if the empty root channels are too large and affect the planting of the main crop.

Competition with primary crop

Growing cover crops or cover crops left to set seed can compete with the next crop during the growing season.

Habitat for insect pests

Some cover crops can host slugs or other pests that overwinter in the soil and become a pest to the following crop. For further information on cover crop suitability, visit the Midwest Cover Crop Council: www.mccc.msu.edu/

Vectors for disease

Some cover crops can host diseases that can overwinter and affect the following crop.

Weeds

If cover crop stands are patchy or provide minimal cover in spring, they may allow weeds to proliferate before crop establishment.

Nutrient depletion by non-legumes

High biomass cereals and other nutrient-scavenging crops can deplete nutrient reserves.

Nutrient availability not timely for subsequent crop

Some cover crops are slow to decompose – releasing nutrients too soon or too early for efficient uptake by primary crop.

Allelopathic effects on primary crop

Poorly selected cover crops can impede germination and early growth with the release of natural allelopathic chemicals.

Increased management and labour costs

It will take time to research and learn which cover crops work best with various field crops. Additional labour will be needed to establish and control the cover crop.



Planting oats early in the fall leads to good soil cover and biomass for plowdown (left). Planting oats late in the season results in a poor stand with little soil coverage and protection against erosion (right). If you must seed late, increase the seeding rate to ensure adequate cover.



Holes in the soil surface after cover crop radish help increase water infiltration, soil air exchanges and soil drying, but can be problematic for no-till planting in spring. Seeds may fall into the root channels and lead to an uneven stand.



White clover and most other legume cover crops fix nitrogen and improve soil tilth – but consider the impact on parasitic nematode populations.

Cover crop radish has been measured as having as much as 100 kg/ha of nitrogen in the above-ground biomass under optimal growing conditions. Ontario research has shown that little of this nitrogen is available to the next crop.

Winter cover crops: making them work

SELECTING COVER CROPS FOR POST-HARVEST CONDITIONS

Growers usually know what they want a post-harvest cover crop to do. At the very least, winter cover crops need to become established during late summer–early fall conditions, grow in the fall and provide enough cover over winter.

Consider the following questions when selecting cover crop types based on characteristics, functions and limitations.

GROWTH HABITS	<ul style="list-style-type: none"> • What kind of growth habit is needed? Fast or slow? • Moderate growth in the early fall or lots of vigorous growth in late fall? • What is the rooting type? Is deep rooting required to break up compaction or fibrous rooting needed to hold soil in place?
OVERWINTERING	<ul style="list-style-type: none"> • Does the cover crop need to survive over winter? • Would it suit the cropping schedule and soil type to have the cover crop winter-killed and dried out by spring?
CONTROL OPTIONS	<ul style="list-style-type: none"> • Will the cover crop become a weed concern in the spring if not properly terminated? • How is it to be controlled in the late fall or early spring? • What options are there for control (tillage or chemical)?
SENSITIVITY TO HERBICIDES	<ul style="list-style-type: none"> • How sensitive is the cover crop to herbicide residues from other crops in the rotation, e.g. radish after peas or beans?
SEED COST AND AVAILABILITY	<ul style="list-style-type: none"> • What is the seed cost and is the seed readily available in your area?
ESTABLISHMENT	<ul style="list-style-type: none"> • Considering the seed size and soil type and condition, what is the best way to plant the seed – broadcast or drilled? • Is different equipment required? • How easy is it to establish in the early fall, mid fall or late fall? • Will it create a solid cover in cool and/or wet conditions? • Is good establishment critical to the success of the cover crop?
NUTRIENT MANAGEMENT	<ul style="list-style-type: none"> • Is it a nitrogen producer or does the cover crop require nitrogen to grow well? • Does the cover crop require other nutrients for successful establishment and growth? • What is the nitrogen cycle and timing of nitrogen release? • Does it scavenge well for nitrogen? • Does it scavenge and release other nutrients?
PEST MANAGEMENT	<ul style="list-style-type: none"> • What crop family is the cover crop in? • Is it related to other crops in the rotation? • Will this crop host pests? • Can this crop break pest cycles?

Cover crops following winter wheat in Ontario have reduced the levels of nitrate left in the soil in October and November by 50% compared to no cover.

ESTABLISHING WINTER COVER CROPS

Timing and method of establishment are determined by the cover crop growth rate, the length of the growing season, and the characteristics of the previous crop.

Planting date. To maximize fall biomass production, most cover crops require 40 to 60 days of growth before a killing frost. Summer-harvested cereals leave enough time in most areas. However, establishing cover crops after fall-harvested corn or soybeans means a much shorter growth period and may not be possible some years or in some parts of the province.

Planting method. In some cases cover crops can be inter-seeded into the main crop. Another option is to plant after harvest by drilling or broadcasting.

TERMINATING COVER CROPS

Have a plan in place for cover crop termination – when and how. Will the cover crop be controlled in the fall, in the spring before the next crop, or after planting?

Some post-harvest cover crops such as oats and radish are killed by winter conditions, while others will need to be controlled with herbicides, tillage, or mechanical control.



Roller-crimpers can be used to knock down and crimp standing cover crops before planting in the spring, provided the correct growth stage has been reached.

CROP COMBINATIONS AND ROTATIONS THAT WORK

Cash Crops and Cover Crops

Proven post-harvest cash crop/fall cover crop combinations:

- ✓ Wheat – midsummer harvest offers many options
 - rye, oats, oats/radish, multi-mix
- ✓ Corn – winter cereals
 - rye or wheat
- ✓ Soybeans/edible beans
 - rye or wheat, or possibly oats if early seeded

Fitting cover crops into the rotation:

- ✓ Corn/soybeans (oats or rye cover crop)/corn



A multi-mix cover crop mixture with oats and oilseed radish fits well after winter wheat in a corn/soybeans/winter wheat rotation.

COVER CROP	COMMENTS	BENEFITS
OATS OR BARLEY	<ul style="list-style-type: none"> • simple • can be used for forage • inexpensive • suitable for broadcast or drill 	<ul style="list-style-type: none"> • quick establishment in mid to late summer • partial to full soil coverage to protect against erosion • nitrogen scavenger • fibrous root system helps bind soil to improve soil structure and protect against erosion • frost-killed
WINTER CEREALS (e.g. rye, wheat, triticale)	<ul style="list-style-type: none"> • requires more management than spring cereals • can be used for pasture or spring forage • inexpensive • suitable for broadcast or drill 	<ul style="list-style-type: none"> • quick establishment in early to mid-fall • less top growth compared to spring cereals, but living cover is more rugged • nitrogen scavenger • fibrous root system helps bind soil to improve soil structure and protect against erosion
MULTI-MIX (grass + legume + brassica oats or rye + clover or peas + radish)	<ul style="list-style-type: none"> • cost varies depending on species used and amount planted • three or more species can be included – select mix carefully to ensure compatibility, i.e. do not use buckwheat • some add sunflowers or other flowering cover crops to support pollinators • drill or broadcast and incorporate if peas or other large seeded crops are in the mix 	<ul style="list-style-type: none"> • variety of growth habits in terms of timing of establishment, ground cover, and root growth all help protect the soil against erosion and improve soil structure • can increase diversity of plants in the cropping system – some species scavenge nutrients in fall to protect against loss and some fix nitrogen in the fall and spring to increase soil N levels for the following crop • biomass helps to maintain soil organic matter

Vegetable Crops and Cover Crops

Cover crop choices will depend mostly on when the vegetable crop is planted and harvested – but do consider the overall crop rotation, any pest concerns, and the cover crop goals.

✓ Aug/early September

- rye, oats, oat/radish, multiple species mixes

✓ Fall – switch to winter cereals

- rye or wheat, triticale

COVER CROPS FOR A PROCESSING TOMATO ROTATION

YEAR	CROP	COVER CROP
1	Processing tomatoes (early harvest)	Oats + radish
2	Corn	
3	Soybeans	Winter wheat
4	Winter wheat	rye
5	Processing tomatoes (early harvest)	Oats + radish



Late-summer seeded oats are a good choice to follow early harvested vegetables.

COVER CROP	COMMENTS	BENEFITS
OATS + RADISH	<ul style="list-style-type: none"> • moderate cost • oats will help radish flow in the drill • broadcast or drill • both will winterkill • plant from mid-August to early September 	<ul style="list-style-type: none"> • oat has fibrous root and radish has a taproot, which help to build soil structure and help protect against erosion • also taproots can help pull nutrients from deeper in the soil • nitrogen scavenger to prevent N loss and improve soil fertility • quick establishment in late summer and early fall • provide complete soil coverage to protect against erosion and suppress weeds • large biomass will grow, and once terminated will add to soil organic carbon levels

PLANTING CONSIDERATIONS

Adjust seeding rates to suit the type of cover crop needed, e.g. forage versus basic soil cover. Cover crops for forage production in addition to soil cover require much heavier seeding rates. A basic cover crop can be created with a much lighter seeding rate to create a general cover for the soil and prevent erosion. Many of these cover crop seeds are small – consider and adjust depths to ensure establishment.

SPECIES	SEEDING RATE KG/HA	NORMAL SEEDING TIME	MINIMUM GERMINATION TEMPERATURE °C	NITROGEN FIXED OR SCAVENGED (F or S) ¹	OVERWINTERING CHARACTERISTICS
GRASSES					
Spring cereals	100–125	Mid-Aug–Sept	9	S	Killed by heavy frost
Winter wheat	100–130	Sept–Oct	3	S	Overwinters very well
Winter rye	100–125	Sept–Oct	1	S	Overwinters very well
Sorghum sudan	50	June–early Aug	18	S	Killed by frost
Pearl millet	4	June–early Aug	18	S	Killed by frost

¹ Oilseed radish and the grasses do not fix nitrogen from the air but are scavengers of nitrogen from soil and manure applications

SPECIES	SEEDING RATE KG/HA	NORMAL SEEDING TIME	MINIMUM GERMINATION TEMPERATURE °C	NITROGEN FIXED OR SCAVENGED (F or S) ¹	OVERWINTERING CHARACTERISTICS
Ryegrass	12–18	Late spring through August	4.5	S	Annual, Italian partially survive; Perennial overwinters
BROADLEAVES – NON-LEGUME					
Radish	2–6	Mid-Aug–early Sept	7	S	Killed by heavy frost
Other brassicas, i.e. forage radish	Varies with species	Mid-Aug–early Sept	5–7	S	Species-dependent, many killed by heavy frost
100 kg/ha = 90 lb/acre					

¹ Oilseed radish and the grasses do not fix nitrogen from the air but are scavengers of nitrogen from soil and manure applications

BENEFITS OF WINTER COVER CROPS

SPECIES	BUILDING SOIL STRUCTURE	WEED SUPPRESSION	NUTRIENT UPTAKE POTENTIAL	QUICK GROWTH	ROOT TYPE
GRASSES					
Spring cereals	Good	Good	Good	Very fast	Fibrous
Winter wheat	Good	Good	Very good	Fast	Fibrous
Winter rye	Very good	Very good	Very good	Very fast	Fibrous
Sorghum sudan	Good	Good/Fair	Very good	Very fast	Coarse fibrous
Pearl millet	Good	Good/Fair	Good	Fast	Coarse fibrous
Ryegrass	Very good	Fair/Poor	Good	Slow to establish	Fibrous
BROADLEAVES – NON-LEGUME					
Oilseed radish	Fair	Very good	Good	Fast	Moderate tap
Other brassicas, i.e. forage radish	Fair	Very good	Good	Fast	Moderate tap

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.

- *Cover Crops: Adaptation and Use of Cover Crops*
omafra.gov.on.ca/english/crops/facts/cover_crops01/cover.htm
- *Cover Crops Following Cereals and Late-Summer Harvested Crops*
omafra.gov.on.ca/english/crops/field/news/croptalk/2014/ct-0614a5.htm
- Publication 811, *Agronomy Guide for Field Crops*
- *Soil Erosion – Causes and Effects*, OMAFRA Factsheet 12-053
omafra.gov.on.ca/english/engineer/facts/12-053.htm

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ACKNOWLEDGEMENTS

This factsheet was developed by the OMAFRA Soils Team: Adam Hayes (Chair), Doug Aspinall, Andrew Barrie, Dave Bray, Christine Brown, Adam Gillespie, Christoph Kessel, Kevin McKague, Jake Munroe, Deanna Nemeth, Nicole Rabe, Jim Ritter, Daniel Saurette, Stewart Sweeney, Ted Taylor, Anne Verhallen

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AF189

ISBN 978-1-4606-9442-8 (Print)

ISBN 978-1-4606-9444-2 (HTML)

ISBN 978-1-4606-9446-6 (PDF)

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