Best Management Practices

ROTATION OF AGRONOMIC CROPS

In the years following World War II through to the 1980s, field crop farming underwent a period of unprecedented growth. Yields, crop quality and farm income all made remarkable gains thanks to production specialization, intensification, increased drainage, and improvements in genetics and inputs. However, evidence of problems in soil health and productivity began to appear, and has increased over time.

There were exceptions to this trend. These were the farms that fed forages and used straw bedding, or used cereals, grasses and legumes to protect their soil over winter. In other words, these farms continued to practise crop rotation.

This factsheet compares continuous cropping and crop rotation systems, outlines what to consider if you want to move to crop rotation, lists tips to making it work, and describes proven crop rotation combinations.

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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Continuous row cropping versus crop rotation

There are two main approaches for cropping systems: continuous cropping and crop rotation.

CONTINUOUS CROPPING

Continuous cropping, where the same crop is grown in a field year after year, will:

- create suitable habitat for crop pests (insects, disease and weeds)
- result in lower crop yields and quality
- degrade soil quality – loss of organic matter, structural degradation and increased risk of erosion.

Continuous row cropping, larger fields, increased drainage and fertilizer, and accelerating chemical responses to increased pest pressures took their toll on soil health. Farm enterprise specialization and the intensification of production led to a reduction in the number of acres managed with crop rotations. Soil organic matter became depleted, soil structure was degraded, and by the 1970s, evidence of erosion was a common sight on Ontario cropland.

Improvements in crop production systems led to unprecedented increases in crop yield and crop quality following the end of World War II. Soil productivity improved and then levelled out, so more tile drainage was installed and fertilizer application rates increased.

Not all soils were degraded during this era: producers who continued to use crop rotation – especially with hay or pasture in the mix – benefited from sustained yields on healthy soils.

CROP ROTATION

Crop rotation, the successive planting of different agronomic crops on the same land, will:

- alter habitat for crop pests and break pest cycles
- maintain crop yields and quality
- sustain soil health.

Crop rotation involves alternating the planted crop from year to year on the same land. A typical short rotation for field cropping systems in Ontario is corn/soybeans/wheat. Including red clover or another suitable legume crop helps to improve soil structure, build organic matter, and supply nitrogen to the next crop.

A longer rotation may include forages like alfalfa, e.g. corn/soybeans/wheat/alfalfa/alfalfa/alfalfa. In both cases a grass and broadleaf crop is alternating through the rotation.

Why continuous cropping doesn't work

REDUCED FERTILITY – Growing the same crop from year to year also results in the same yearly pattern of nutrient removal from soil reserves during crop growth and harvest, and nutrient return to the soil from crop residues, resulting in a shift in nutrient balances.

INCREASED PEST PRESSURE – Pests (weeds, disease, and insects) thrive on specific crops (hosts), in specific environments, and at specific times of the year. Growing the same crop from year to year provides a predictable environment for the pest, which allows it to persist from year to year (overwintering pests especially).

INCREASED EROSION AND RUNOFF – Poor soil structure results in susceptibility to wind and water erosion, soil compaction, surface runoff and offsite transport of sediments into adjacent surface water.

DEGRADATION OF SOIL STRUCTURE – Growing the same crop each year means the same planting, tillage, and harvesting pattern year after year, which damages the soil structure. Specifically, mono-tilling at the same time and depth and in the same way year after year leads to plowpans, broken aggregates and overall soil structural damage.

Why crop rotation works

Crop rotation promotes soil health in important ways. But it's not all about soil health. Crop rotations have many benefits and functions that help make cropping systems more effective and successful.

DISEASE PREVENTION – Crop rotations are an essential management strategy to control crop diseases. Numerous organisms cause root rot symptoms on dry edible beans. In Ontario, the four main fungal pathogens are *Fusarium, Pythium, Rhizoctonia* and *Charla*. These organisms can occur individually or in combination, as is often the case. This is referred to as "root rot complex." Crop rotation is one of the key recommended preventative practices to reduce the risk of these diseases.

WEED CONTROL – Most perennial weeds are susceptible to late-summer or fall herbicide applications. Further, by rotating herbicides, weed control is more effective for each crop and the overall risk of herbicide resistance is reduced. Crop rotation provides more windows of opportunity to control weeds. Fall burndowns are made possible when summer-harvested cereals are part of the rotation.

INSECT CONTROL – Rotations disturb the life cycle of insects and other invertebrate pests. For example, growing alfalfa in rotation with corn disrupts the habitat conditions and life cycle of corn rootworm – providing effective pest control without the need for pest control products.

REDUCED INPUTS – Fewer crop inputs are required when growing crops in rotation. Corn following soybeans, for example, receives a 30 kg N per hectare credit and does not require a soil insecticide for rootworm. This can save up to $50 per hectare.

SOIL TILTH – Forages and pasture crops will add organic matter and remediate soil structure to improve tilth. This improves infiltration and water storage – while reducing the risk of runoff. Soils managed with a forage-based rotation are more healthy and resilient to most forms of soil degradation.

GROWTH AND YIELD – In most cases crop rotations improve yield. Corn following soybeans will often yield up to 20% more than continuous corn on the same farm. Yield responses to crop rotation of 15% for soybeans and 10% for wheat are common.

SOIL ORGANIC MATTER – Alternating plant growth patterns means providing erosion protection differently from year to year in terms of row spacing, canopy cover, plant density, and returned residue after harvest. Moreover, root systems and exudates from crops differ (legumes providing more stability than grasses), which helps to aggregate the soil, build organic matter and consequently hold it in place.

REDUCED GREENHOUSE GAS EMISSIONS – Crop rotations – when combined with cover crops and less tillage – can help reduce greenhouse gas emissions of carbon dioxide and nitrous oxide. Longer-term rotations with forages will serve as a carbon sink by adding organic matter to the soil.

LOW MAINTENANCE – Some crops – like cereals – require very little tillage to establish, provide cover over winter, and leave the soil undisturbed until the next planting season.

BUT DOES IT PAY?

For crop rotations to be cost-effective, rotational crops must have enough profit potential to pay for the additional machinery, labour, and storage costs that they require. For example, it is difficult for grain producers to utilize long hay rotations with row crops because of the large amount of labour required for haymaking.

There are some initial costs for implementing crop rotations, such as extra equipment. (Equipment sharing or custom work may be an option instead of buying.) But in the final analysis, these costs may be more than overcome by the reduced inputs, timeliness, and higher yields realized over the long run – offering a more sustainable return on investment.

NUTRIENT USE EFFICIENCY – A well-planned rotation can contribute to more efficient use of plant nutrients. In a three-year corn/alfalfa rotation, for example, manure can be applied during the corn phase of the rotation, resulting in efficient use of the N and often a buildup of P and K levels.

During the alfalfa phase of the rotation, when manure is not applied, the forage crop will utilize the soil P and K levels that were built up during the corn phase of the rotation. This combination of nutrient management and crop rotation can reduce or eliminate the need for purchased fertilizer.

What to consider if you're thinking about crop rotation

- ✓ **Available equipment** – additional crops in a rotation may mean that equipment needs to be modified, rented or purchased to plant, fertilize, spray, and harvest.
- ✓ **On-farm crop needs** (livestock producers) – if you are a livestock producer, adding a forage to the rotation makes sense. Consider adding forage to the rotation and selling it to livestock producers in need.
- ✓ **Market situation** – commodity prices drive crop selection to some extent. What results in the most returns today may damage the soil and affect crop yield in the future. Forages are not typically the most revenue-generating crop, but they are the most helpful for the soil and result in yield boosts for the following crop.
- ✓ **Input costs** (seed, fertilizer, pesticides) – different crops in the rotation will mean different input needs. However, the overall effect of a good rotation means less fertilizer and less pesticide, especially if forage is included.
- ✓ **Economics of the whole rotation** – consider the whole rotation when calculating economics, not the individual crop years. Lower input costs and yield boost effects of the rotation can be masked if yearly economics are calculated.
- ✓ **Effects of current crop on the following crop** – consider implications regarding pests, remaining residue, herbicide carry-over.

Canola produces a chemical that causes corn stunting and overall poor plant health. Research into the effects of this type of interaction is critical to make crop rotations work.

Good rotation needs to include at least three different crops in a grass, broadleaf, grass pattern (corn/soybeans/wheat).

COMPARE PROFITABILITY OF ROTATIONS

The Cashcropper app allows Ontario grain growers to compare the net profitability and fertility requirements for different crop rotations within a given field. It takes into account the user's location, soil type and tillage practices for corn, soybeans and wheat. Users can input their own data to assess real and hypothetical rotation decisions. Download the app at www.cashcropper.ca.

Tips to make crop rotation work for you

- ✓ Generate a plan and select crops that work for your system, and stick to it.
- ✓ Inoculate soybeans if growing them for the first time.
- ✓ If a legume doesn't work for your system, a cereal (fibrous root system) must be included to get the benefits of rotation.
- ✓ Including an underseeded red clover into wheat increases corn yields and overall benefits from the rotation.
- ✓ Rotate a high residue crop with a low residue crop to maintain sufficient residue cover on the field.
- ✓ Know any interactions between crops in consecutive years. Disease and depressed yields are often seen when a crop follows itself in a rotation.
- ✓ Monitor and keep crop records. Fine-tune the system as needed.

Making new crop rotations work takes monitoring and fine-tuning.

Make cereals part of your rotation. Their fibrous rooting system improves seedbed structure.

Agronomic crop rotations that work

Here are some typical crop rotations with well-proven track records.

CORN/SOYBEAN/WHEAT ROTATIONS

Including wheat will break pest cycles and reduce weed problems that develop over time. Wheat following soybeans is an excellent sequence. Earlier maturing soybeans and no-tilling wheat into bean stubble provides a good disease-free seedling environment for wheat.

One challenge with this rotation in a no-till system is that it can leave a mat of residue, keeping the soil cool and wet and thereby limiting the succeeding no-till corn crop's potential. Some growers are trying to alleviate the situation by using a broadleaf cover crop (e.g. buckwheat, radish) following wheat, using a fall herbicide treatment to kill any existing weeds and create an overwinter dead mulch, or by incorporating some tillage in their program at this point in the rotation.

CORN/ SOYBEAN/ WINTER WHEAT/ RED CLOVER ROTATIONS

Winter-seeding red clover into the winter wheat in the spring can provide a green manure or possibly a forage crop before rotation back to corn.

On some poorly drained soils, yields of continuous corn declined under no-till. But when corn/soybean/ wheat or corn/ oat/hay rotation are used, no-till corn yields are similar to conventional corn yields.

White mould is also a significant issue in soybeans that are grown in a short rotation.

CORN/HAY ROTATIONS

A corn/hay rotation is common on many dairy and beef farms. Corn usually follows an alfalfa-grass forage mix to maximize residual nitrogen and benefit from improved seedbed structure and reduced pest pressures.

This rotation is most successful when hay rotations are relatively short (i.e. three to four years), because few corn fields on the farm will be more than one or two years away from a perennial forage crop. Longer hay rotations result in lower hay yields, more potential damage from some insects that prefer grassy hayfields (such as wireworm, white grub, and common stalk borer), and corn yields that decline in the third and fourth year after hay.

A long corn/alfalfa rotation can be broken up by planting soybeans after two years of corn or by following soybeans with wheat as a nurse crop for the alfalfa-grass mixture. One alternative to long corn rotations between alfalfa plantings is to grow a soybean crop after two years of corn and follow it with two more years of corn.

AGRONOMIC CROPS AND PROPERTIES TO CONSIDER WHEN PLANNING CROP ROTATIONS

CROP	BENEFITS AND CHARACTERISTICS	PRECAUTIONS
ALFALFA, CLOVERS	• Nitrogen fixing for non-legumes • Deep rooting opens soil pores • Reduced soil erosion • Planting is in spring, either alone or inter-seeded into a cereal, or in summer following a cereal harvest • Source of food for pollinators	• High removal of potassium • May be difficult to market • Poor growth of alfalfa on acid soils • Alfalfa difficult to establish on poorly drained soils
GRAIN CORN	• High levels of residue, which add organic matter • Tolerant to broad range of herbicides for weed control • Early spring planting, harvest later fall	• Potential disease problems in wheat following corn • Late harvest does not allow timely planting of fall-seeded crops or tillage
SOYBEANS	• Yield improvements after corn • Herbicide selection offers good control of grass weeds • Later spring planting allows quackgrass control before planting • Early fall harvest allows planting of fall seeded crops • As a legume, it fixes its own nitrogen but does not leave an excess for the next crop	• Preparing a fine seedbed will destroy soil structure and the small root system will do little to improve it • Slow to cover ground with vegetation, especially when grown in rows
WINTER CEREALS	• Fall planting season shifts workload, reduces amount of land to till in fall, provides winter cover • Harvest in summer • Extensive root systems improve soil structure • Strong competition with weeds so the cost of chemical weed control is low	• Large volumes of straw can form mat on ground after harvest • Rye stubble may inhibit corn growth and reduce yields
SPRING CEREALS	• Planting season in early spring, before corn • Harvest in summer • Similar properties to winter cereals	

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* omafra.gov.on.ca/english/crops/facts/cover_crops01/cover.htm
- *Soil Fertility Handbook,* Publication 611

Best Management Practices Series

- *Controlling Soil Erosion on the Farm*
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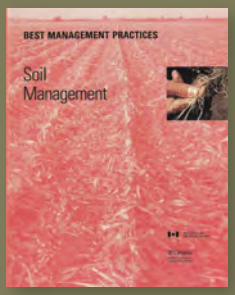

Environmental Farm Plan (4th ed.) and EFP Infosheets

- #15, *Soil Management*
- #16, *Managing Nutrients in Growing Crops*
- #18, *Horticultural Production*
- #19, *Field Crop Production*

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