Best Management Practices

COLD AND WET SOILS

Cold and wet soils are two conditions that impact planting and seed germination. There are two types of soils that are chronically or seasonally cold and wet – naturally cold and wet soils and degraded soils.

Soils that are naturally cold and wet are often found in low-lying field positions. They are most closely aligned with the poor to very poor soil drainage classes, and are called "gleysolic" or water saturated soils.

Degraded soils, (e.g., compacted soils), can interfere with normal water infiltration rates and, in extreme cases, may cause the formation of a perched water table. This occurs when compaction reduces the downward movement of water moving through the soil profile, resulting in the soil surface being temporarily saturated while the soil below the compaction is unsaturated. This temporary saturation can lead to further compaction and increased degradation of the soil.

This infosheet describes a set of diagnostic tools used to describe the type, nature and extent of cold and wet cropland in Ontario. Proper diagnosis is essential to identify the most suitable best management practices (BMPs) for a given field.

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 a crops 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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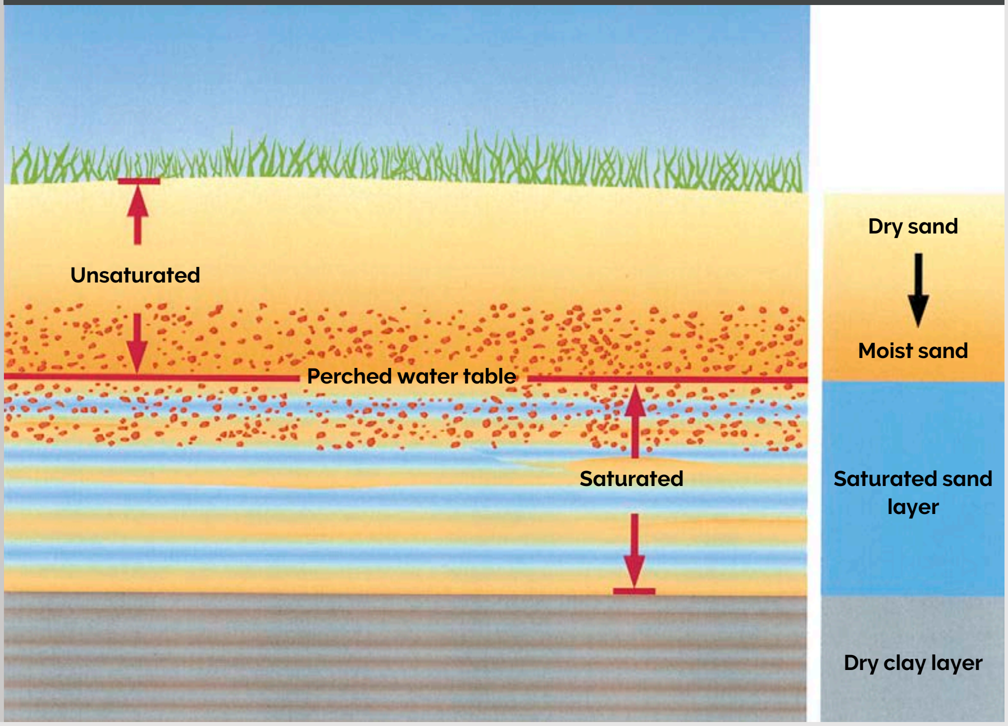
Gleysolic soils are characterized by grey colouring and a shiny surface or sheen caused by short- to long-term anaerobic (zero oxygen) conditions.

Soils that are temporarily saturated near the surface (making them wet and cold) and are unsaturated below the compacted layer are considered to have an artificial perched water table. These layers of temporary saturation can lead to increased compaction and further degradation.

PERCHED WATER TABLE

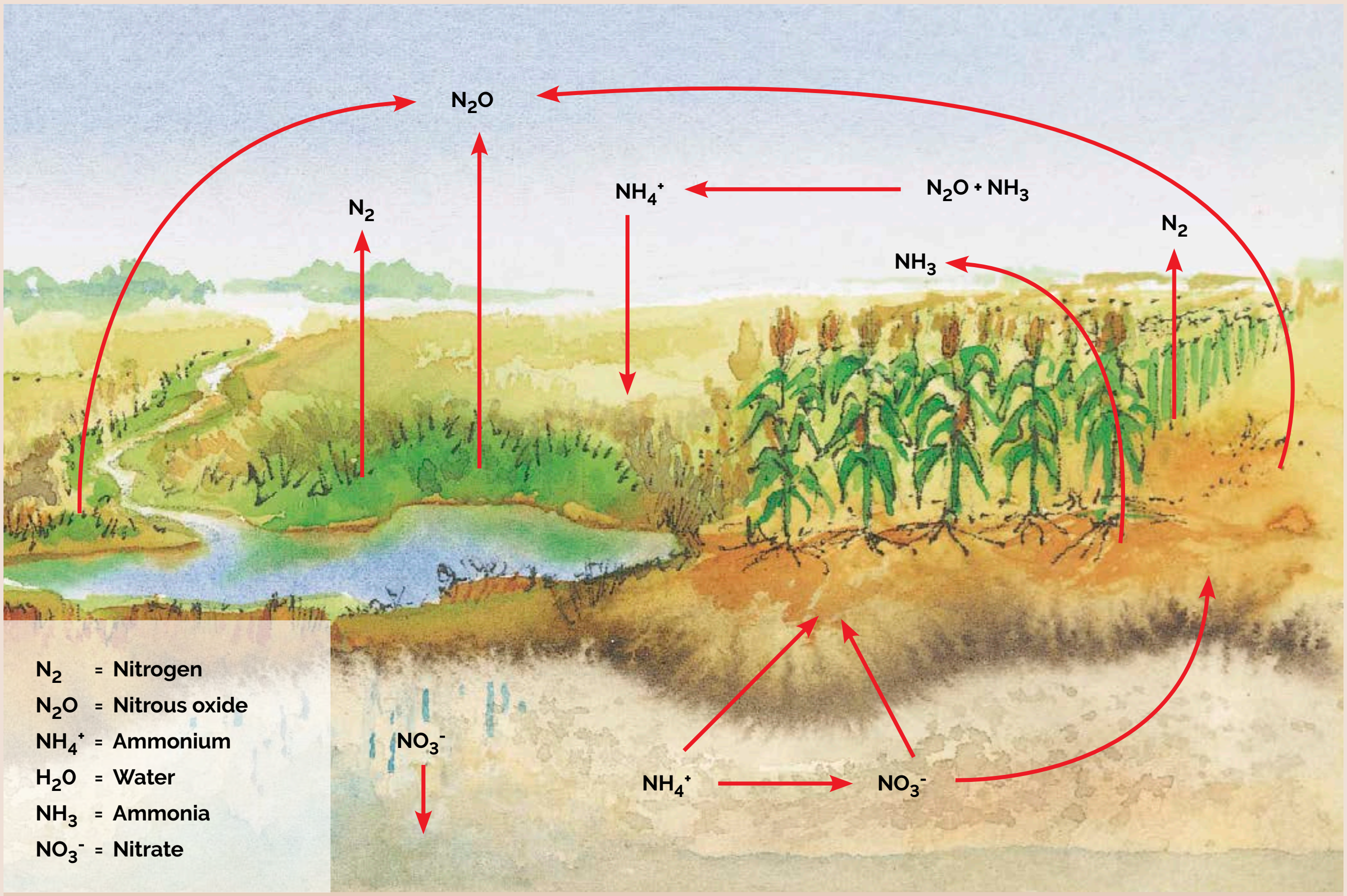


Cold and Wet Soils and Soil Health

Wet soils are more prone to crusting and compaction from field operations. Wet and cold soil conditions pose a higher risk for loss of nitrogen from denitrification or leaching. Partial denitrification will cause the emission of nitrous oxide — a powerful greenhouse gas. In cold and wet soils, crops suffer from poor root establishment, delayed emergence, uneven crop stand and slow growth rates.

Compaction and poorly structured soils lead to runoff and erosion, and the deposition of sediment and crop nutrients into adjacent surface waters.

Lowland areas of fields are typically cooler and slower to drain, especially if compacted. These areas are often subject to year-long flooding, which can lead to little or no germination of the crop.



Cold and wet soils are prone to leaching and anaerobic conditions. These processes of leaching and denitrification reduce the nitrogen available to the crop within a field, and lead to nutrient enrichment off the field and/or in nearby waterbodies and groundwater.

Cold and Wet Soils: The Basics

In order to manage cold and wet soils, it's helpful to first understand the principles and processes of soil water and groundwater.

INFILTRATION

Infiltration is the process where water enters the soil surface and displaces air. The rate of infiltration is directly related to local topography, surface soil properties, and site conditions.

Bare soils with poor seedbed conditions have low infiltration rates due to poor soil structure and low connected porosity. Some soils (e.g., silty and clayey soils) may have inherently low infiltration rates due to the alignment of the soil particles within the aggregates. Silty and very fine sandy soils have weaker aggregates and are more likely to crust, as can clayey soils with poor aggregate stability due to excessive tillage and low organic matter content.

Lowland areas collect water from upper areas of the field, leaving excessive amounts of water to infiltrate the soil. Due to the sheer volume of water standing on the soil surface and in the soil profile, it takes more time for water to move into and through soils with standing water. Other factors that contribute to low infiltration rates in lowland areas are compaction, soil crusting (sealing), and buried soil profiles (i.e., the A horizon of the soil is buried by depositions of eroded soil).

Lower infiltration rates caused by localized soil degradation are a soil management issue that can be corrected with soil BMPs, such as hooking up a drop inlet structure to an existing subsurface pipe.

A drop inlet structure will help to remove ponded water from cropland areas with low infiltration rates.

PERMEABILITY

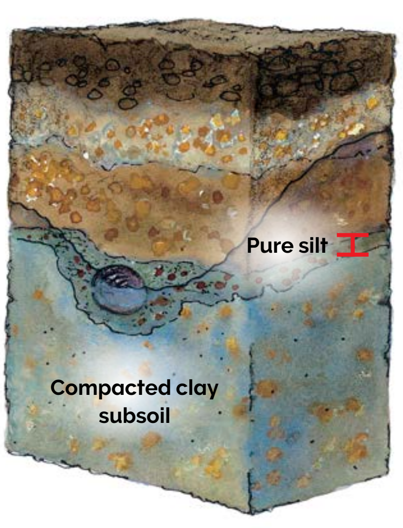
Once water moves into the soil, gravity helps it move from near the surface down through the soil profile. "Hydraulic conductivity" is the rate at which water passes through (permeates) the soil. This rate is linked to soil porosity, texture, structure, depth to restricting layer (bedrock, hardpan or fine textured soil), and depth to water table. Soils with a low hydraulic conductivity tend to be cold and wet during the growing season.

The concept of hydraulic conductivity is captured in the system used to describe natural soil drainage in the field. Soils that are rapidly drained are sandy, highly porous and have no restricting layer or evidence of a soil water table within 1 m (3 ft) of the soil surface. Poorly drained soils have a high (shallow) water table and are usually less porous than rapidly drained soils.

The soil drainage classification system is used to describe soils in soil survey maps and reports. There are seven soil drainage classes — from very rapid to very poor. Wet and cold soils are usually rated as poorly drained.

Soils with a low hydraulic conductivity are sometimes described as impermeable soils, or having lower-than-ideal permeability for crop growth and field operations.

IMPERMEABLE SOIL



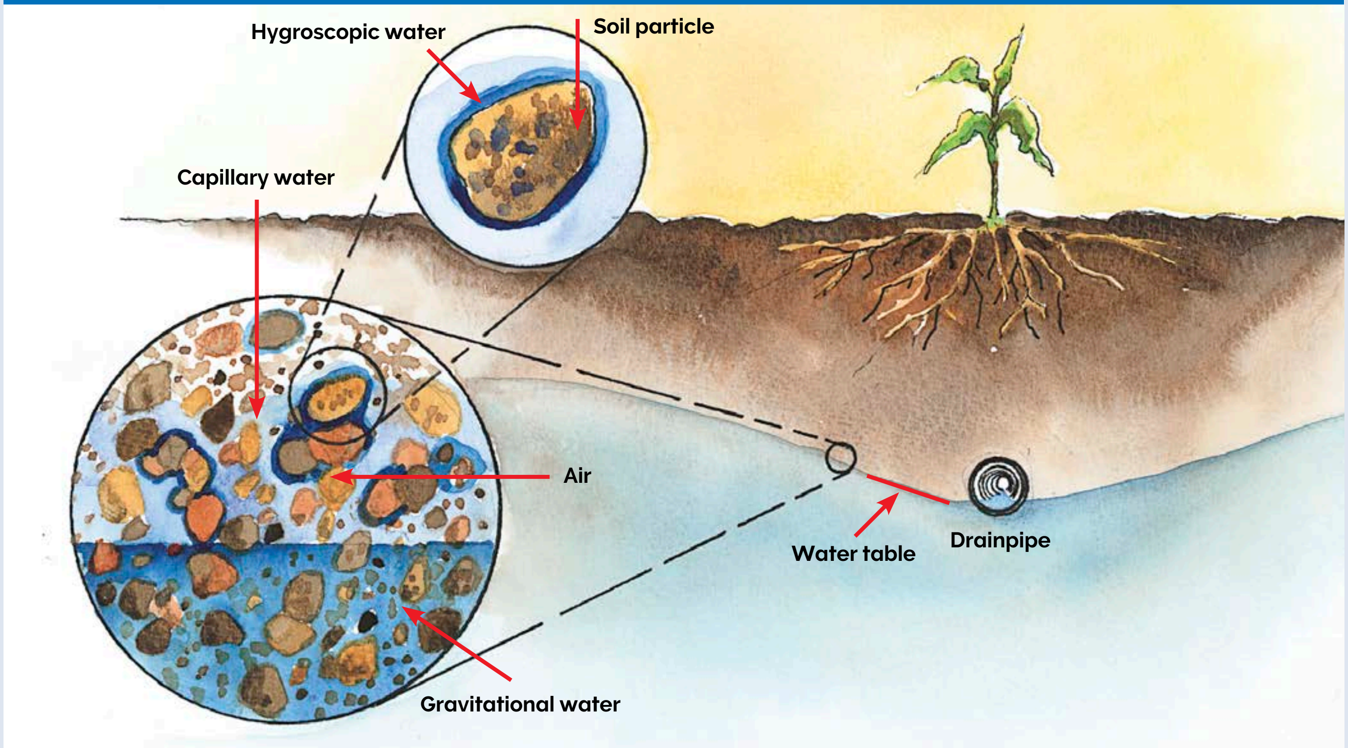
SOIL WATER

Not all soil water is equal. Some is held so tightly that it is virtually unavailable to plants. Other soil water flows freely and isn't held in soil. The amount and availability of soil water is critical to crop uptake and metabolic requirements, as well as temperature, tilth, soil aeration and crop root exploration.

Soil water can be classified as:

- gravitational (excess water)
- capillary (available to plants), or
- hygroscopic (water held tightly by soil particles)

SOIL WATER



There are three types of soil water: gravitational (excess water), capillary water (available to plants) and hygroscopic water (held tightly by soil particles).

The amount of available soil water closely follows soil texture:

- loams, silt loams and clay loams hold the most available water
- clay soils have high surface areas and many fine pores, and the highest proportion of hygroscopic water.

Available soil moisture is the amount of water between the permanent wilting point (PWP) and field capacity (FC).

Permanent wilting point is the lowest level of soil moisture a plant requires to avoid irreversible wilting.

Field capacity is the maximum volume of water a soil can hold onto against gravity in capillary pores. If more water is added, it will drain naturally (due to gravity).

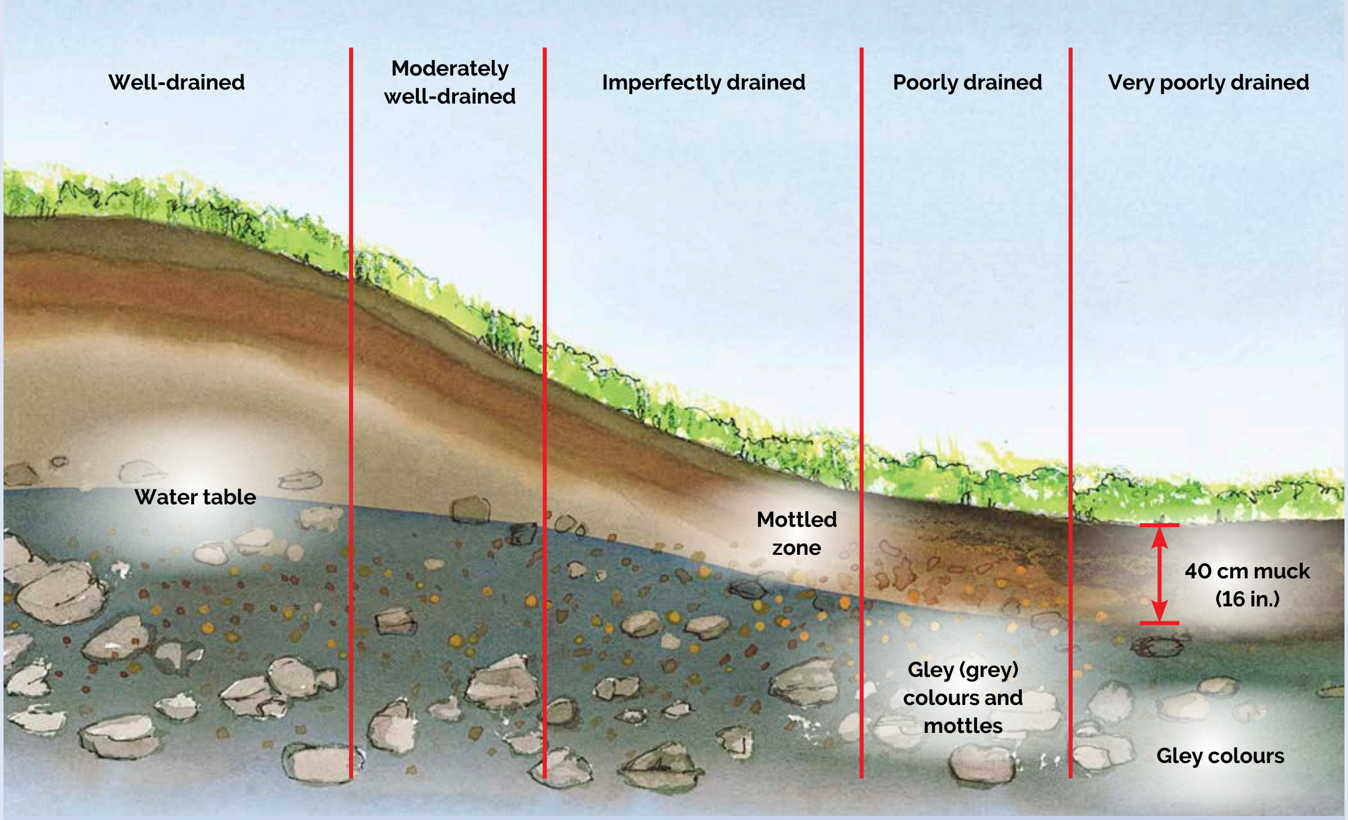
Cold and wet soils are usually saturated or have moisture contents beyond field capacity. Permeability is too low, and with high water tables there is no place for gravitational water to drain.

WATER TABLE

The upper surface of groundwater is called the water table. The water table's depth fluctuates over the year according to levels of precipitation, evapotranspiration and deep percolation. In late fall, precipitation generally exceeds evapotranspiration rates, causing the water table to rise.

The water table stays high and peaks in early spring following snowmelt and accumulated rainfall. The water table drops throughout the growing season as crops mature and precipitation falls off (normally) in July and August.

Soils with a high water table are prone to wet and cold conditions.



Soil colours provide a good indication of the seasonal fluctuations of soil water tables. Dull, grey (gley) colours indicate zones or depths of permanent saturation, whereas layers with rust spots (mottles) indicate a fluctuating water table. Soil water tables normally mimic local topography, but tend to be deeper on hills and knolls and closer to the surface in depressional areas.

SOIL DEGRADATION AND COLD AND WET SOILS

Soils in low lying field areas are inherently cold and wet. The soil's natural condition can deteriorate if subjected to untimely tillage, unnecessary tillage, high axle-load traffic when soils are wet, poor crop rotation practices, wet harvests, and no addition of organic amendments or crop residue cover.

With prolonged use of these practices, seedbed and subsurface structure will deteriorate, causing crusting and the formation of plow pans and deeper compacted layers.

Structurally degraded soils in low lying-to-level site positions will impede infiltration and percolation, causing soils to become wetter at the surface.

SOIL TEMPERATURE

Soil temperatures are directly related to air temperatures. Wet soils take longer to warm up because of the high specific heat of water, which means it takes a lot of energy to heat the soil water (compared to the air above the soil). Dark soils absorb heat and warm up more quickly. South-facing slopes receive more direct solar radiation.

Snow cover and lighter soil colours reflect radiation and do not warm up as quickly. Even though color and texture impact how quickly soil warms up, it is the soil water in cold climates that plays the largest role in the soil warming process in the early spring. Therefore, it is important for soils to drain well.

Wet or moist soils have a higher heat capacity than dry soils, and undisturbed soils can absorb more heat than recently cultivated soils. This means that bare, moist and undisturbed soil surfaces will absorb more radiant energy during the day and will provide increased frost protection by releasing this heat during the night. Soils in depressional or lower-slope site conditions are exposed to cooler air temperatures, as cold air moves to the lowest points in the landscape.

Dark soils — those with high levels of soil organic matter — absorb heat more quickly.

CONDITIONS FOR COLD AND WET SOILS

Topography

- depressions are often wetter and colder

Soil profile conditions

- heavy textured soils
  - clay soils warm up slowly and have slower drainage rates
- low organic matter soils
  - soils with low organic matter are typically lighter in colour and will not absorb heat as quickly as dark-coloured soils that are high in organic matter
- drainage class and high-water tables
  - poor or very poor drainage classes
- perched water tables
  - natural and those created by subsoil compaction
- soil surface "albedo" (albedo refers to how reflective something is; comparing the amount of light hitting the surface to the amount of light that gets reflected, expressed as a percentage)
  - dark wet soils have an albedo of 6–15% (e.g., paved parking lot is @5%)
  - dry soils have an albedo of 22–34% (e.g., concrete pad is @25%)

Climate conditions

- precipitation patterns
  - frequent heavy rains will make soils cold and wet
- local climate
  - some regions have shorter growing seasons, fewer frost-free days and wetter springs and falls
- deep snowpack
  - deep snow and slow snowmelt will keep soils colder and wetter longer

Snow collecting in low-lying areas of a field or fencerows will be slower to melt, making the soil colder and wetter for longer in the spring.

Past and present management

Practices that lead to compaction and poor soil structure include:

- heavy axle loads
- high tire pressure
- uncontrolled or random traffic patterns
- field operations while soil is wet
  - wet soils have less resistance to compaction than dry soils
  - wet soils are more plastic and malleable to physical forces such as smearing and compaction
- excessive tillage (e.g., more than 3 passes)
- excessive residue cover in spring, preventing soils from warming up
  - soil with weathered corn residue has an albedo of 22%
- low-lying fields with no subsurface drainage
- crop rotations with too few crop types
  - degrade soil structure over time
  - lack of diverse rooting systems to aid in building soil structure and enhancing drainage

DIAGNOSTICS for Cold and Wet Soils

There are several ways to diagnose cold and wet soils in your cropland.

FIELD OBSERVATIONS

- delayed weed flush once temperatures increase
- ponding in level or depressional areas
- runoff from ponded depressions
- slow to dry in spring

Ponded water in wheel tracks and minor depressions in a field indicate cold wet conditions likely caused by compaction.

Fields with hummocky terrain (i.e., knolls and mounds) often contain many cold and wet depressional areas.

CROP OBSERVATIONS

- poor germination
  - pronounced in wet or depressional areas
  - seeds may swell but not sprout
  - more insect and disease seed loss due to delayed emergence
- seedlings affected by a number of disorders
  - tip dieback, stunting, poor growth
  - purple tint or anthocyanin response on corn seedlings, indicating stress
- soil-borne diseases associated with dampness
  - smut, damping-off, white rot
- nitrogen deficiencies
  - paleness or yellowing of older leaves first

Stunted and N-deficient corn in depressional areas is evidence of soils that are cold and wet in the spring and for the early part of the growing season.

- restricted root and shoot growth
  - root depth limited due to waterlogged soil
  - stunted crop growth
- young plants may develop yellow leaves due to slow photosynthesis
- poor crop vigor
- lodging due to excessively wet and cold soils during initial nodal root formation
- frost heaving of perennial crops
- areas of dead crops
  - mainly in depressional areas or headlands

SOIL OBSERVATIONS

- saturated soils
- soil cold to the touch
- grey (gley) soil colours within 50 cm (20 in.) from surface
- prominent mottles (rust-spots) within 50 cm (20 in.) of soil surface
- poor soil structure
  - crusting, plow pans and subsurface compaction
  - mottling and gley near compacted zones
  - evidence of artificially perched water tables
- rutting and compaction
  - measured by an increase in bulk density

Seedlings will not develop properly in cold and wet soils. These winter wheat seedlings are showing stunted growth and evidence of nutrient deficiency.

Sandy soils are considered rapidly drained if there is no evidence of water table activity (i.e., no mottles or gley colours in the top metre of the soil).

Sandy soils can be cold and wet when located in lower-slope positions, depressional areas and level fields. In most cases, gley colours and mottles are found in the upper 50 cm (20 in.) of the soil profile — indicating a poor soil drainage class. If only gley colours are found — and no mottled zone — the soils are classed as very poorly drained.

Suitable Best Management Practices (BMPs)

BMPs are classed as preventative or remedial. Often a combination of two or more BMPs (or suite of BMPs) is the most effective approach to resolve soil problems.

Choose the most suitable suite of BMPs from the following:

- timely tillage and field operations
  - avoid working the soil until it is fit
- Controlled Traffic Farming (CTF), and/or permanent tramlines
  - reduce the area of the field subjected to compacting forces
- harvest-assist equipment (e.g., trucks, grain buggy and tractors) kept in headlands
  - keep the heaviest equipment out of the field during vulnerable soil conditions
- reduced tillage frequency or intensity
  - minimized disturbance of soil aggregates allows them to re-form
- reduce tillage area
  - strip-tillage will help to dry out seedbeds while maintaining overall soil structure
- improved drainage systems
  - install subsurface pipe or surface inlets
- crop rotation
  - diversity of root systems improves soil structure and internal drainage
- disease-resistant varieties and seed treatments as required to protect against disease and insects during germination
- cover crops
  - enhance soil organic matter, improve soil structure, harvest excess water
- residue management
  - keeping residue standing allows soil to dry out more quickly in the spring, encourages earthworms to form drainage pores
- rotation of perennial or deep-rooted crops
  - can establish deep root channels that improve percolation and drainage
- land retirement
  - to wetland or to permanent vegetation if inherent limitations are too severe to be managed


Best Management Practices
SUBSURFACE DRAINAGE

Subsurface drainage will remove excess gravitational water and reduce the risk of soils experiencing growing conditions that are too cold and wet for crop production.

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 ServiceOntario.

- *Agronomy Guide,* Publication 811
- *Soil Fertility Handbook,* Publication 611

Best Management Practices Series

- *Controlling Soil Erosion on the Farm*
- *Cropland Drainage*
- *No-Till: Making It Work*
- *Soil Management*

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

- Worksheet #15, *Soil Management*

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ADDITIONAL RESOURCES

Manitoba Agriculture, Food, and Rural Development. Wet soils influence soil fertility. http://www.gov.mb.ca/agriculture/crops/soil-fertility/wet-soils-influence-soil-fertility.html

Michigan State University. Cold, wet soils and vegetable seed emergence. http://msue.anr.msu.edu/news/cold_wet_soils_and_vegetable_seed_emergence

USDA. Estimating Soil Moisture by Feel and Appearance. http://nrcspad.sc.egov.usda.gov/DistributionCenter/pdf.aspx?productID=199

USDA. Soil Quality: Managing Cool, Wet Soils. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_053277.pdf

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