Best Management Practices

SURFACE CRUSTING

Surface crusts are thin, massive layers that form on the surface of a structurally weakened, bare seedbed after a wetting event (heavy rainfall or series of rain events).

Surface crusts in seedbeds are a key form of soil degradation. Left unchecked, surface crusts can lead to other soil health problems such as reduced water infiltration, poor exchange of gases between the soil and the atmosphere, ponding, and increased rates of erosion and runoff.

These crusts can also form a physical barrier that will hinder the emergence of newly germinated crops. Crusting can lead to poor and uneven crop emergence, crop loss, and in some cases, replant costs.

This infosheet explains how soil crusts form, symptoms to look for in fields, crops and soils, and best management practices (BMPs) to help prevent and resolve surface crusting issues.

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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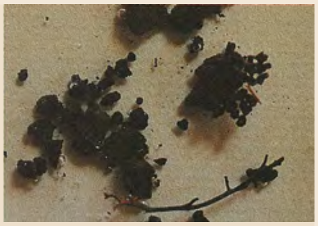
What happens in a crusting-prone soil following a storm event

The crusting process starts with a bare soil condition – like a prepared soil/seedbed. The condition of the prepared soil is typically granular and "fluffy" before planting.

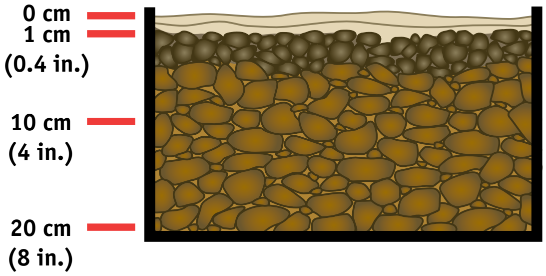
During a heavy rain, raindrop impact can disperse and further pulverize the already broken-up soil aggregates on the soil surface. Dispersion can be like a small explosion – separating aggregates into primary particles of sand, silt, clay and organic matter. Rain and infiltration soften the soil – increasing the soil's plasticity and friability and decreasing its strength.

At first, less stable aggregates will continue to disperse and swell. But once the soil is saturated and all air-filled pores are replaced by water, the top layer of soil will slump (settle). If the rate of rainfall or pooling of surface water exceeds infiltration and percolation rates, water will pond on the soil surface.

Some of the finer soil particles, including clays, silts and humus, will detach and become suspended in the ponded water. Once the excess ponded water runs off, evaporates or eventually infiltrates, then the particles in suspension will resettle on the surface.

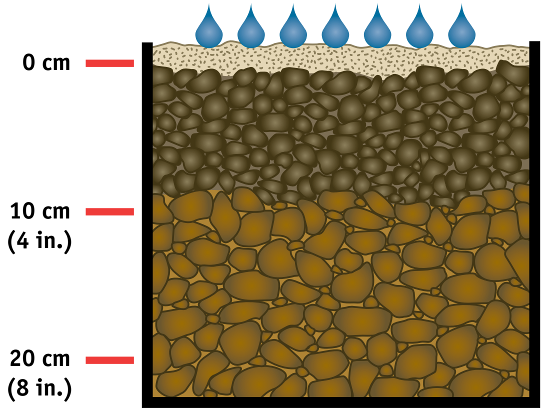


The risk of crusting increases as the strength of aggregates decreases. One way to illustrate this is to compare the durability of seedbed aggregates from different management regimes by immersing samples in water. Unstable aggregates break down sooner. In the pair of photos above, the one on the left is from a seedbed that is continuously row cropped, while the one on the right is from an adjacent woodlot with the same soil type (series).



As the saturated soil dries out due to evaporation, a vacuum is created in the macropores. This negative pressure sucks the small particles (clay and silts) that just settled on the surface into any newly emptied macropore spaces. In some cases, silt and clay particles will form distinct layers in the crusts (also known as "varves").

"Field capacity" is the amount of soil moisture held in soil pores after excess water has drained away. If the moisture content in the upper 5 cm (2 in.) of the soil drops below field capacity, the density will increase as pores have been in-filled by soil particles. If soil aggregates are weak (i.e., not water-stable), the thickness of the dense surface layer will increase – thereby forming a surface crust. Soil material below the crust may not be affected by the wetting and drying process.



Following a rainfall event, weak seedbed aggregates will disperse and become suspended in small puddles formed on the soil surface. Suspended soil particles will resettle to form crusts on the soil surface.

Conditions where surface crusting is likely

SOIL CHARACTERISTICS

- Texture
  - Soils with 10–35% clay and less than 2% organic matter (sandy loams to clay loams) are more prone to crusting.
  - Silty soils such as silt loams and silty clay loams with weak aggregates are more prone to crusting.
- Structure and aggregate stability
  - Fine, weak aggregates are prone to crusting.
- Bulk density and porosity
  - Soils with a distinct plow pan (compacted at 10–20 cm or 4–8 in.) in depth, low porosity, or a low proportion of macropores will reduce infiltration rates and permeability – which will accelerate saturation of the soil surface, ponding and crusting.
- Drainage
  - Poorly drained soils or soil/site positions where subsurface drainage systems are less effective are more prone to ponding and crusting.

TOPOGRAPHY

- Topography is complex and rolling with in-slope depressional areas and level-to-depressional fields – this is where water will pond.

PAST AND PRESENT MANAGEMENT

- Tillage practices have been poorly timed – too wet or too dry.
- Intensive tillage has led to breakdown of organic matter and soil structure:
  - fine seedbed preparations of 3 passes or more can pulverize soil aggregates
  - disc and/or packer or roller are used, which can smear finely worked, weak seedbed.
- Soil is compacted from tillage or traffic, which can reduce percolation rates.
- Short or no crop rotation results in minimal organic matter additions and no soil cover.
- Minimal crop residue leaves soil surface bare.
- No cover crops are planted, so that soil has no cover and minimal organic matter additions.
- Grazing is allowed on saturated soils.

Frequent or intensive tillage pulverizes peds (aggregates) and leads to the rapid breakdown of organic matter. Organic matter helps to bind soil particles into stable aggregates, acting like a cushion for rainfall impact on the soil surface. The finer the seedbed, the greater the risk of crusting.

Diagnostics for surface crusting

FIELD OBSERVATIONS

- Extensive or frequent surface ponding
  - on clay plains with silty seedbeds, whole fields can be crusted – especially those that have been laser-levelled
- Runoff from smaller ponded areas in field
- Field conditions go from too wet to too dry within a few days
- Wind erosion where level fields have high sand content
- Low plant populations due to poor emergence
- Large or local areas dominated by surface crusts

CROP OBSERVATIONS

- Uneven, spotty, delayed emergence
- Hypocotyl (i.e., stem under seed leaves) hooked at surface – still under crusted soil
- Hypocotyl broken at surface
- Crop leafs out under surface
- Stunted growth (delayed start)
- Restricted root growth due to reduced aeration
- Nutrient deficiencies or general discoloration
- Yield reductions

A layer of crust on the soil surface prevents water from entering the soil. In fact, reduced infiltration can lead to ponding, concentrated flow, channelized in-field erosion, cropland runoff, and deposition of sediment, nutrients and organic matter into adjacent surface waters.

Severe crusting will prevent crops from emerging.

Surface crusting often follows surface ponding. Look for ponded areas in fields, especially in depressional areas.

Later in the growing season, look for areas with stunted growth and evidence of past puddling/ crusting on the soil surface.

SOIL OBSERVATIONS

- Fine, weak and water-unstable aggregates covering the seedbed
- Seedbed conditions weakening with the onset of each crop year
- Smooth or crusted massive surface when wet (can be shiny if clay texture)
- Flakey surface structure once dry
- Granular or blocky soil structure underneath hard surface layer
- Platy structure at depth of tillage (look for plow pan)

This photo gives a cross-section view of a surface crust. Note how the layers of soil are sorted into particle sizes: very fine sand at the top, silt in the middle, and fine sands at the bottom. In healthy soils, particle sizes are found in aggregates – bound by humus and clay particles.

Weak granular or blocky structures are often found directly below the formed surface crusts. It is not uncommon to find a plow pan of platy structure below it. Soil particles may form distinct layers once the newly formed crust dries. Soil particles may also shrink to form prismatic (6-sided) structures. Roots have been observed to grow on the edge of these soil structural forms.

The surface of a crusted soil looks like one large sheet of hard soil, about 1 cm (0.4 in.) thick.

For more information about structure and density below the soil surface, refer to *Subsurface Compaction,* a BMPs for Soil Health Diagnostic Infosheet.

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SUBSURFACE COMPACTION

Subsurface compaction occurs in the subsoil at a depth of more than 10 cm (4 in.). It is the compression of subsoil aggregates and particles into a smaller volume by the actions of tillage, traffic, or both.

Soil compaction is a form of soil degradation. Compacted soils have a higher bulk density, lower porosity, and lower proportion of macropores. Compaction affects air and water exchange in the soil profile and restricts root growth.

Reduced porosity means reduced air and water movement in the soil. This leads to saturated soils and anaerobic conditions at the soil surface. Saturated soils are more susceptible to denitrification and runoff.

This infosheet presents a set of diagnostic tools used to describe the type, nature and extent of subsurface compaction of Ontario soils. Proper diagnosis is essential to identify the most suitable best management practices (BMPs) for a given field.

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Best management practices (BMPs)

✓ Conservation tillage (no-till, mulch tillage) – reduces pulverization of soil aggregates.

✓ Crop rotation – varies tillage patterns, adds organic matter and cover, allowing soil structure to stabilize.

✓ Cover crops – add organic matter and cover the soil, allowing soil aggregates to become more stable.

✓ Residue management – protects soil surface from rain impact.

✓ Organic amendments – increase soil organic matter and strengthen aggregates.

✓ Surface water management/drainage structures, e.g., surface inlets – remove ponding water.

✓ Repair or modification of subsurface drainage system – improves infiltration and reduces ponding.

✓ Grazing management (lower grazing density) – reduces surface compaction.

✓ Rotary hoe if crust forms as short-term relief measure – breaks up a weak crust with one pass with surface tillage.

✓ Planting technology adjustments – maximize effectiveness, e.g., planters may provide better seed placement than drills, especially in no-till systems.

Regular additions of organic amendments can improve the stability of aggregates and reduce the risk of crusting.

Fibrous cereal and grass sod roots help to improve soil structure and increase soil resilience to setting up layers based on particle size and crusting.

Well-timed and executed mitigation measures, such as breaking up the crust with a rotary hoe as shown above, can provide short-term relief. However, they won't prevent surface crusting from recurring.

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

Best Management Practices Series

- *Buffer Strips*
- *Controlling Soil Erosion on the Farm*
- *No-Till: Making It Work*
- *Soil Management*

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

- #15, *Soil Management*

Inquiries to the Ontario Ministry of Agriculture, Food and Rural Affairs

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This infosheet was developed by the OMAFRA Soils Team: Adam Hayes (Chair), Doug Aspinall, Andrew Barrie, Sebastien Beillard, 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

Research and Writing: Ann Huber, Don King, Margaret Ribey, Soil Research Group (SRG)

Technical Coordinators: H.J. Smith, Ted Taylor

Editorial Coordinator: Alison Lane

Design: Neglia Design

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