Soil Properties and Management IF-03

Figure 1. Understanding and managing soils is key to improving soil health (Manitoba Soil Science Society).

What does soil management accomplish?

The objective of soil management is to ***Improve Soil Health.*** Producers traditionally manage their soils to improve crop productivity and increase the long-term sustainability of the land.

Tile drainage changes how water moves across and through the soil which, in turn, affects soil properties such as moisture content, depth to water table, structure, infiltration and salinity. These changes reduce excess moisture, improve trafficability and reduce the risk of soil compaction, resulting in more flexibility for field operations and cropping choices.

Soil management practices should be modified to optimize the tile drainage system and realize the full potential of the field following installation.

> ***Healthy soil, an essential component of a healthy environment, is the foundation upon which sustainable agriculture is built.***
>
> Source: Acton and Gregorich, 1995

Overview of soil properties and management

Soil properties that are affected by water inherently must then be altered by the introduction of tile drainage.

In some instances, a tile drainage system will reduce the severity of existing problems such as soil salinity, excess moisture and the risk of surface compaction. By ridding the field of excess water earlier in the growing season, tile drainage may make it possible to modify the crop rotation, tillage practices and the timing of field operations. On the other hand, tile drainage discharge to particularly sensitive parts of the watershed may warrant more intensive soil management to reduce or avoid negative environmental impacts.

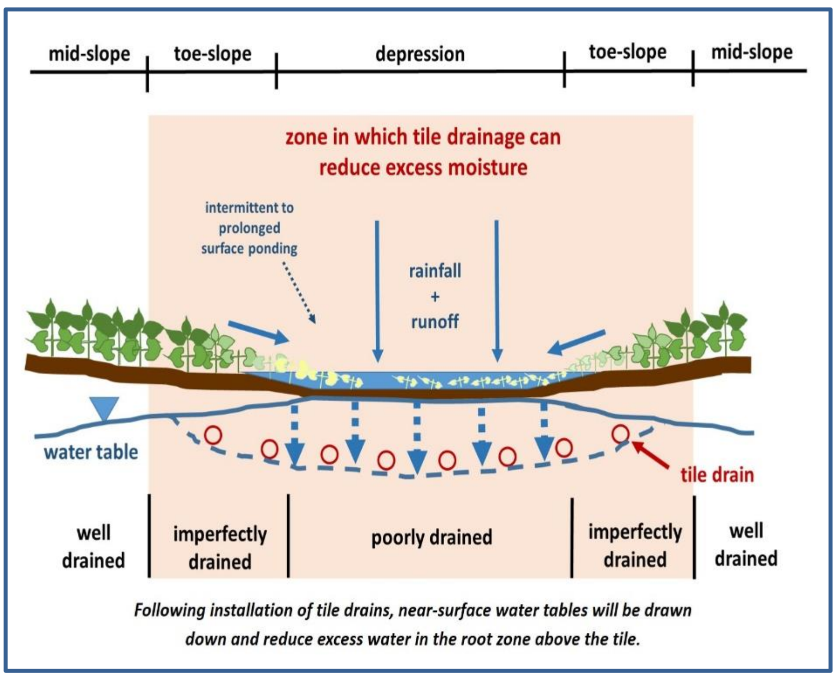

Figure 2. Zone of beneficial impact on soil wetness in relation to drainage class, landscape position and depth to water table.

With the adoption of tile drainage, the combination of soil management practices to be employed by a producer should complement a farm's cropping system and realize the full potential of the drainage improvements while minimizing downstream impacts.

Applicability of soils properties and management in Manitoba

Soil management principles are broadly applicable across agri-Manitoba. The suitability of particular soil management practices depends on the tile drainage system as well as the properties of a given field. A management program must be customized to fit each farm's unique combination of climate, soil types, landscape conditions, crop rotation, equipment options and fertilization practices.

Soil salinity

Imperfectly and poorly drained soils can be prone to and affected by salinity (Figure 2 and 3) which can limit productivity. Saline soils typically develop where near-surface water tables bring salt-laden groundwater to the soil surface, where salts are deposited and accumulate over time.

Tile drainage lowers the water table, promoting the percolation of "fresh" water through the root zone which leaches soluble salts through the soil and into tile drains (Figure 3). The implementation of tile drainage can thus be an effective means of reducing existing salinity in the soil zone above the tile drains and minimizing the potential for future salinity development. However, a decline in salinity following the implementation of tile drainage is a long-term process, controlled by the volume of fresh water moving through the soil profile and into tile drains. Soil management practices to promote reclamation of salt-affected areas include snow capture, enhancing infiltration while limiting surface runoff, and inhibiting preferential flow.

Prior to implementing tile drainage, producers should understand the degree and extent of salinity in their targeted fields and have reasonable expectations for the change in soil salinity levels over time. Additionally, the discharge of salts with tile drainage is a concern for downstream surface water quality and land quality if surface drainage downstream of the tiled land is inadequate.

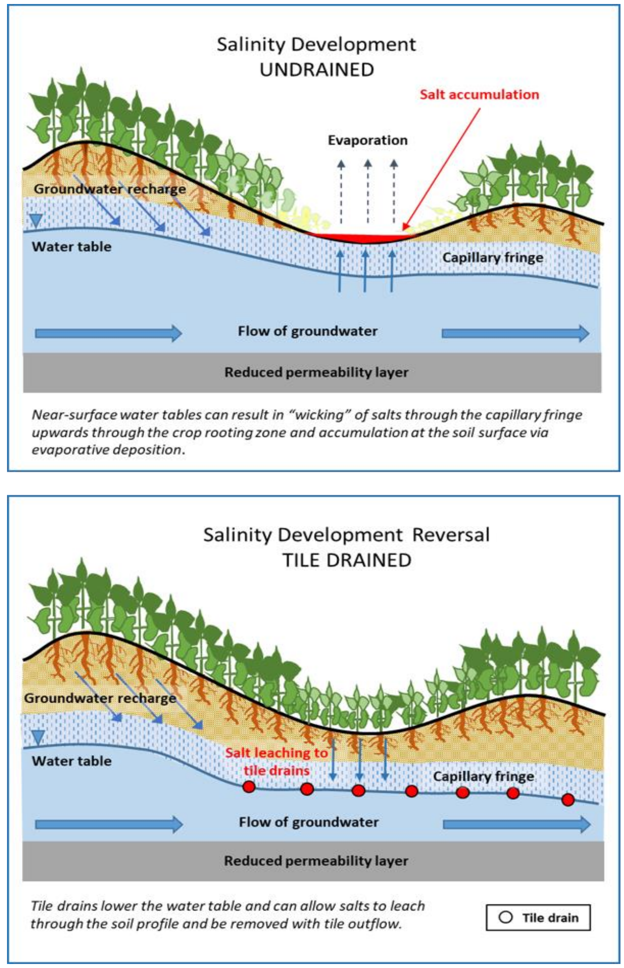

Figure 3. Salinity development in undrained condition and reversal under tile drainage.

> ***"The only real reclamation procedure for saline soils is to drain the excess water off the bottom and pour fresh water on the top to flush the salts out and away."***
> Source: Les Henry, 1990

The following steps should be taken where salinity is a limitation to crop production:

- Soils should be evaluated prior to drainage improvements (soil sampling and EM/Veris mapping) and monitored regularly (e.g. every three years) after tile installation to track changes in salinity degree and extent (see BMP EA-01 – Professional Services);
- To reduce salt loading in tile discharge, tiles should be installed no deeper than is necessary to achieve minimum agronomic objectives (see BMP IF-05 – Site-Specific Tile Drainage Design);
- Tile water discharge should be monitored to assess salt loading to surface water.

Soil sodicity

Sodicity is the term describing a soil condition caused by concentrations of sodium that are elevated in absolute and high relative to calcium and magnesium. A sodic soil exhibits poor soil structure due to the dispersion of clay particles (e.g. sodicity-induced, sub-surface impermeable layer or hardpan; Figure 4). This may negatively impact infiltration (surface water ponding) and water movement through the soil (low hydraulic conductivity). Sodicity often, though not always, co-occurs with salinity. Affected areas may be localized and small in size.

A tile nework installed in or below a zone of sodic or saline-sodic soil may not function properly or decline in efficacy over time (Cihacek et al., 2012).

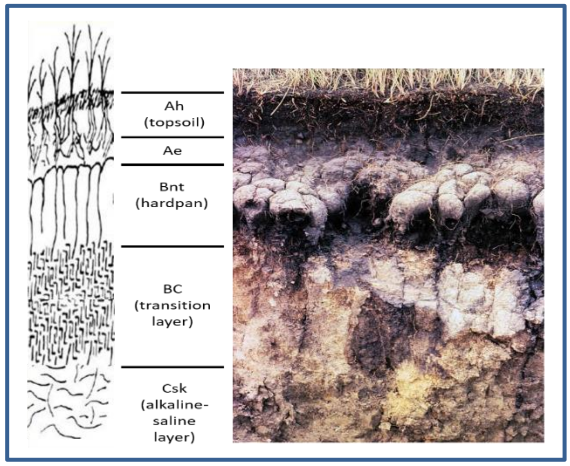

Figure 4. Schematic representation and photo of sodicity-induced, poor soil structure (modified from Alberta Agriculture, Food and Rural Development).

Where sodicity may be a limitation, soils should be:

- evaluated prior to tile drainage implementation (soil sampling and professional advice; see BMP EA-01 – Professional Services) to assess the risk of sodicity hampering tile system performance;
- avoided when installing a tile network, should sodic or saline-sodic conditions be confirmed (i.e. sodium adsorption ratio [SAR] values >13 or exchangeable sodium percentage [ESP] >15; AAFRD, 2010). These soils should be left undrained and, if performance of annual crops is consistently poor, should be seeded to permanent, perennial vegetation;
- monitored regularly (e.g. every three years) to track changes in the degree and extent of sodicity.

Where sodicity is determined to be at deleterious levels following implementation of tile drainage, soil amendments such as gypsum can be applied to reduce the effect of sodium on soil structure (Kalwar et al., 2016).

Soil compaction

Agricultural producers in Manitoba are typically under pressure to conduct field operations as soon as possible in the spring due to a short growing season, and are often faced with the challenge of wet soils. The use of heavy field equipment on wet soils can cause compaction, rutting and smearing (Figure 5), which increases the density of the soil, hampering infiltration of water, soil air movement, seedling emergence and root growth, ultimately reducing yield. Tile drainage lowers the water table following spring snowmelt and heavy rainfalls, improves infiltration and creates better soil conditions for field operations (Figure 5). This decreases the risk of surface compaction and degradation of soil structure, which has both agronomic and environmental benefits.

Figure 5. Rutting in wet soils (left) and improved trafficability under drained conditions (right).

Recommended practices to reduce compaction and improve soil structure include:

- Minimize the number of tillage passes; however, tillage may be necessary to disrupt macropores prior to nutrient application (see IF-01 – Nutrient Management);
- Reuse travel paths to reduce the number of wheel tracks. The first pass accounts for up to 80% of the compaction that four passes would cause on the same spot (Soil Management Guide, 2008).
- Correctly ballast tractors;
- Consider dual, triple, larger tires, lower tire pressure and/or tracks to minimize compaction;
- Maintain and enhance soil organic matter levels for good soil tilth;
- Incorporate cover crops in the rotation to further reduce soil moisture levels;
- Use deep tillage and incorporate deep-rooted crops into the rotation to break up deeper compaction.

Outstanding questions and potential future improvements

Tile drainage can effectively reduce soil salinity; however, leached salts are discharged into surface water at the tile outlet. The relationship between measured soil salinity (e.g. EM38 or Veris mapping) and tile water quality needs to be studied to guide tile design and accceptable discharge standards for salt-affected fields.

Further research is required to confirm the efficacy of soil amendments such as gypsum in addressing sodicity on tile-drained land (Kalwar et al., 2016).

Complementary practices

Soil management is complementary to other BMPs in *improving soil health*.

- *IF-01 – Nutrient Management;*
- *IF-02 – Cover Crops;*
- *EA-01 – Professional Services.*

Manitoba soil resource information

Manitoba Agriculture AgriMaps viewer https://agrimaps.gov.mb.ca/agrimaps/.
Soil Management Guide, 2008. Manitoba Agriculture.

Additional BMP resources

NDSU, 2012. Evaluation of Soils for Suitability for Tile Drainage Performance Extension Service Publication SF1617.
NDSU, 2016. Soil Testing Unproductive Areas Extension Service Publication SF1809.

References

Acton, D.F. and L.J. Gregorich (eds.), 1995. The health of our soils - toward sustainable agriculture in Canada. Centre for Land and Biological Resources Research, Research Branch, Agriculture and Agri-Food Canada, Ottawa, ON.

Cihacek, L.J., Franzen, D., Jia, X., Johnson, R., and Scherer, T. 2012. Evaluation of Soils for Suitability for Tile Drainage Performance. NDSU Extension Service Publication SF1617.

Kalwar, N., DeSutter, T., Franzen, D., and Augustin, C. 2016. Soil Testing Unproductive Areas. NDSU Extension Services Publication SF1809.