Soil Salinity in Nova Scotia High Tunnels

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When evaporation from the soil surface and transpiration from plants exceeds water input, salts can start to accumulate at the soil surface. When water from the soil surface evaporates, it wicks salts that are suspended in the soil solution to the soil surface ***(Figure 1).***

Under the right conditions, as much as 50% of water loss can be due to evaporation from the soil surface. High tunnels, caterpillars, or hoop houses, when left covered and cropped year-round, are particularly susceptible to salinity buildup, especially when all moisture comes through drip tape, which concentrates a wetting event to a small area.

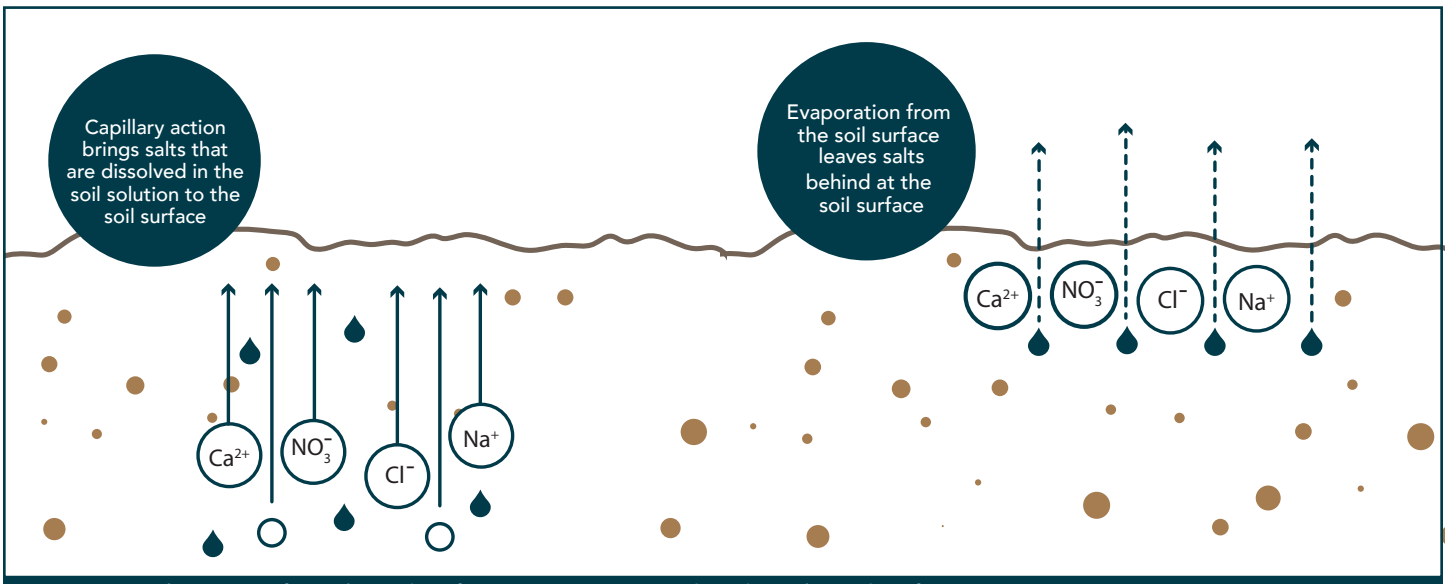

Figure 1. When water from the soil surface evaporates, it wicks salt to the soil surface.

Over time, sometimes as little as three years of intensive production, salt crystals can be observed clinging to soil aggregates ***(Figure 2).***

Figure 2. Salts crystalizing on the soil surface

Accumulating salts are not just sodium (Na^+) and chloride (Cl^-) ions, but are also essential plant nutrients: calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^+), ammonium (NH_4^+), hydrogen (H^+), phosphate (HPO_4^{2-}), sulfate (SO_4^{2-}), and nitrate (NO_3^-) are all salts. Nitrate accumulation is particularly frequent in high tunnels as high-value crops are well fertilized, and since there is no rainfall to leach the nutrients, they accumulate year after year.

WHY SOIL SALINITY IS A CONCERN

In saline soils, plants have a reduced ability to take up water. Plants exposed to saline soils can easily become water stressed. Different crops are more or less tolerant to saline soils (*Table 1*). Salt injury symptoms can manifest as necrosis (death or burning) along the leaf margins, wilting, stunted plants with smaller leaves and shorter stature, and in severe cases, crop death. Plants can also be injured due to the accumulation of specific salts to toxic levels (i.e. sodium, chloride, or sulfate), which can cause nutrient imbalances resulting in the appearance of nutrient deficiencies of potassium and calcium. Saline soils can also adversely affect soil structure.

Table 1. Crop sensitivity to salinity

VERY SENSITIVE (<0.40 mmhos/cm)	SOMEWHAT SENSITIVE (0.40 – 0.80 mmhos/cm)	SOMEWHAT TOLERANT (0.81 – 1.20 mmhos/cm)	MORE TOLERANT (1.21 – 1.60 mmhos/cm)
Beans (some cultivars)[1]	Carrots[1]	Broccoli[1]	Beets[1]
Carrots (some cultivars)[1]	Lettuce[1]	Potatoes[1]	
Eggplant[2]	Okra[2]	Tomatoes[2]	
Muskmelons[2]	Onions[1]		
Strawberry[2]	Pea[2]		
	Peppers[1]		
	Spinach[2]		

[1] https://extension.psu.edu/saline-soils-and-plant-growth?, based on a 1:2 soil:water test. Expect 25-50% decrease in yield under these conditions.
[2] Machado and Serralheiro 2017.

Plants that are more salt tolerant either do not take up excess salts, or do take up those salts but then have the ability to excrete them through the leaves. Other plants have the ability to store excess salts in cells.

HOW TO MEASURE SOIL SALINITY

The way that salinity is measured is through electrical conductivity (EC). Pure water is a poor conductor of electricity, but when water contains ions such as NO_3^-, Na^+, and so forth, it can conduct electricity. The greater the concentration of ions or salts in the soil solution, the more electricity that is conducted. At the Nova Scotia Department of Agriculture (NSDA) soils lab, Conductivity is as an add-on to your typical soil test for an additional charge. It is a good practice to regularly test the EC of high tunnel soils or other protected culture structures. The results will be communicated on the NSDA soil test as "Conductivity", which is in millimhos per centimeter (mmhos/cm). This is the same as decisiemens per meter (dS/m); these two units can be used interchangeably. For example, 0.80 mmhos/cm is the same as 0.80 dS/m.

> The NSDA lab uses a 1:2 soil:water method. Other methods use a 1:1 soil:water method or a paste method, and the results between the three methods cannot necessarily be compared. If you are reading additional literature about soil salinity, remember to compare results that are based on a 1:2 soil:water EC method.

HOW TO PREVENT SALINE SOILS IN HIGH TUNNELS

Plastic or organic mulch can help reduce the amount of water lost from the soil surface through evaporation which will minimize the wicking effect that brings salts close to the soil surface.

The buildup of salinity can often be attributed to the consistent use of drip irrigation without other forms of irrigation. Typically drip irrigation makes sense from a disease management standpoint. To prevent the buildup of salts, it is worth incorporating overhead irrigation as part of your standard practice at logical times during the growing season (prior to planting the fall crop for example). This "maintenance leaching" will help bring some of the salts/nutrients that have accumulated at the soil surface over the course of the growing season down into the root zone where they can be taken up by the crop.

Additionally, incorporating crop residues or green manures will improve soil structure, soil tilth, and water infiltration. Regular additions of crop residue and green manures can provide a safeguard against the buildup of soil salinity.

WHAT TO DO ABOUT SALINE SOILS

Expose the soil to rain
If your farm has the capacity to do so, consider removing the plastic from your high tunnel over the winter every few years. Winter precipitation will help leach the salts from the soil surface. As the water moves down into the soil profile, it will carry dissolved salts with it. This loss in production over the winter season has a cost, but so do yield reductions due to saline soils. Some high tunnel systems are built on runners so that the high tunnel can be easily moved to a new area every year. This will also help reduce salt build up. ***(Figure 3).***

Deep tillage
Tilling the soil deeply will mix salts that have accumulated on the soil surface with a greater volume of soil, deeper in the soil profile. This will reduce the concentration of salts for a short time. Deep tillage will also break up a hardpan, which can be a cause of soil salinity as the hardpan can prevent salts from leaching properly.

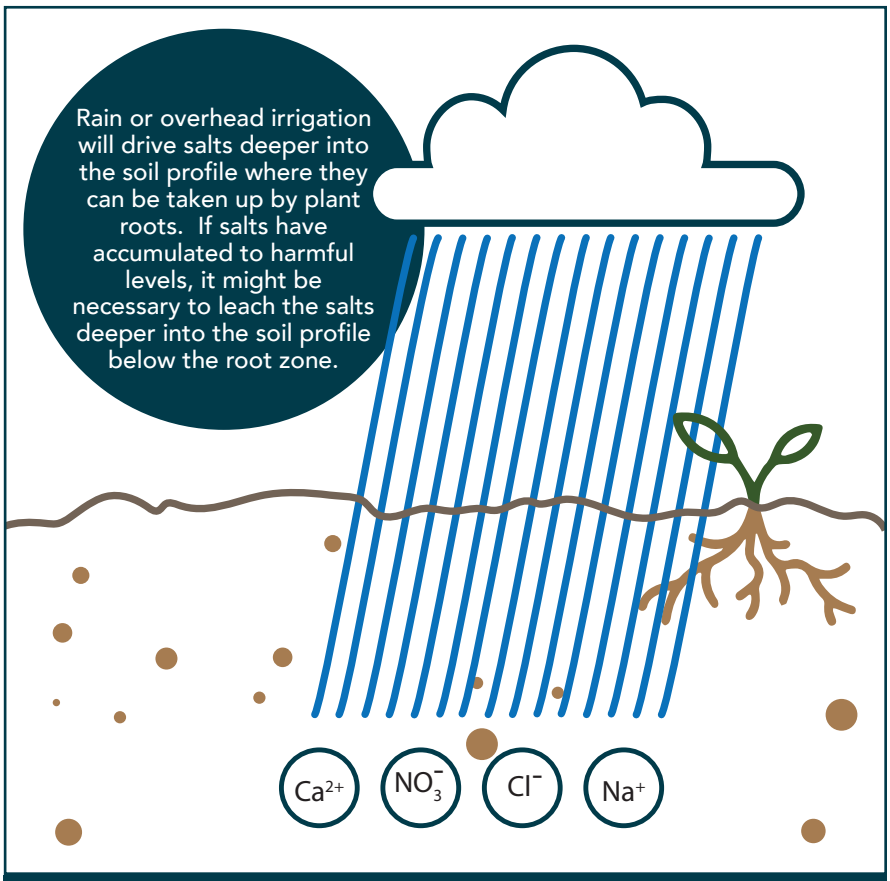

Figure 3. Rain or overhead irrigation can leach salts deeper into the soil profile

Soil Amendments
Should you have highly saline soils due to a buildup of sodium (Na^+), applications of gypsum ($CaSO_4$) can be beneficial as the calcium (Ca^{2+}) will replace Na^+ ions in the cation exchange complex. This will allow the Na^+ to leach away out of the root zone with excess water. However, often high salinity in Nova Scotia high tunnels is due to more than just high sodium levels, in which case gypsum will not be as effective. Talk to your Perennia Specialist to determine if gypsum would be a good option for you.

Flooding
Flooding can also be used to leach the salts deeper into the soil profile (***Figure 3).*** Fresh water is ponded on the soil surface and allowed to infiltrate. However, if you have a hardpan deeper in the soil profile that prevents soil drainage, flooding will not be effective at leaching salts. Deep tillage combined with flooding might be advisable. If you typically have a high water table throughout the year, moving your tunnel to a new location where tile drainage is installed might be your best option.

A rough rule of thumb is that the depth of water added will remove 80% of salts from that depth of soil. For example, 6" of water will remove nearly 80% of salts from 6" of soil, and 30 cm of water will remove nearly 80% of salts from 30 cm of soil.

If you choose to flood the soils in your high tunnel, it is important to consider the quality of the water that you are using to do this. "Hard" water can have Ca, Mg, Na, Cl, B, S, or other "salty" elements, which can raise the soluble salts in the soil profile and actually make the problem worse! Using collected rainwater can help offset this problem.

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