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Salinity Matters for High Tunnels and Growing Media: How to Interpret Salinity Test Results

High tunnels or hoop houses are popular season-extending tools used by urban farmers, vegetable producers, and cut flower growers. High tunnels protect crops from excessive rain and keep foliage dry, which can reduce the spread of disease. However, soaking rains are beneficial for leaching salt accumulated from fertilizers, compost and minerals in the irrigation water below the root zone. Over time, a lack of soaking rains can result in a build-up of minerals in high tunnel soil, increasing the soil's salinity. A mineral build-up sometimes appears as a white crust on the surface of high tunnel soil (Figure 1).

Salinity is an important consideration for management of healthy soil and growing media, particularly in high tunnels or hoop houses. Electrical conductivity measures salinity, or the total amount of soluble salts or minerals in the soil or growing medium. If you are growing in a high tunnel or mixing your own growing medium, measuring the salinity of your soil or substrate is a best management practice that will help you produce better crops.

In a high tunnel, we recommend measuring salinity biannually, so that you can monitor salt buildup over the growing season and any reductions that may have occurred over the winter if tunnels are uncovered or soil is leached by other methods. It's time to assess why and what to do when salinity measurements are increasing or are above 1.2 mS/c. If salinity is a problem, the high-tunnel soil should be exposed to rainfall, which can leach the minerals out of the root zone. Penn State Extension has a helpful article by Sanchez (2017) on next steps for salinity management in high tunnels.

What Happens if Salinity is too High?

Basically, when soil salinity is too high, it is harder for crops to pull water and nutrients into their roots. At very high levels, salinity can stunt root growth. This is the same thing as when people say a high-nitrogen fertilizer can "burn" seedlings' roots.

Figure 1: Crusting on surface of high tunnel growing medium, where electrical conductivity measured 10 mS/cm. Photo by Neith Little, UMD Extension.

White crusting on soil is one indicator of salinity, but how can you spot the problem before it gets that bad? You can send a sample off to a lab (UME, ANMP 2018) or use an *electrical conductivity* (EC) probe to measure salinity in soil and growing media. A simple probe costs about $150, and measures both EC and pH.

Electrical conductivity is a measure of the degree to which a specified material conducts electricity. In soil or growing media, EC is a measure of salts or minerals dissolved in solution (the water in soil pores). The more salt in the soil, the higher the conductivity.

You can use several procedures to measure EC in soil or growing media:

- Professional analytical laboratories often use a method called "saturated media extract."
- The "1:2 media extraction" is a very simple method appropriate for regular monitoring of soils and growing media in high tunnels and raised beds (Figure 2).
- The "pour-through method" is appropriate for growers using pots or small containers (British Columbia Ministry of Agriculture (BACA), 2015).

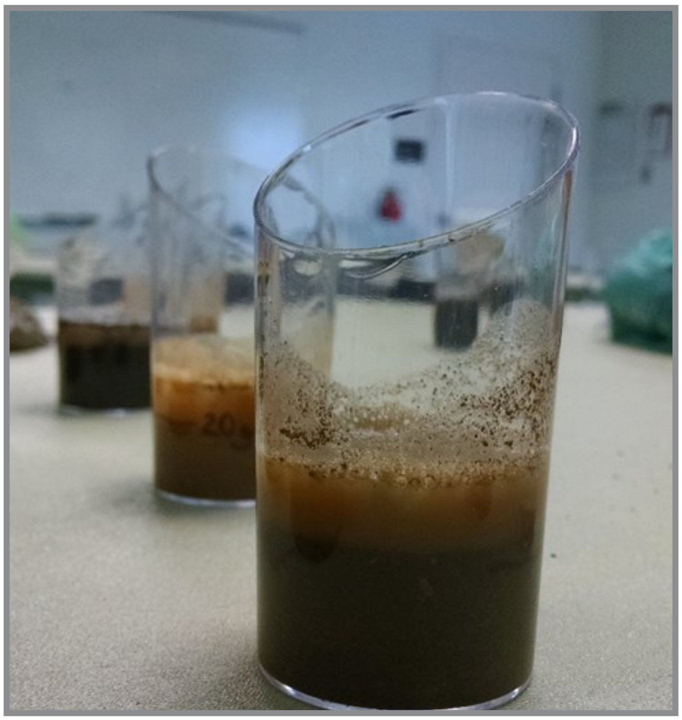

Figure 2: One part growing medium mixed with two parts water for electrical conductivity measurement using the "1:2 media extraction" method. Photo by Neith Little, UMD Extension.

The Siemens is a Derived Metric Unit of Electrical Conductivity, Though Other Measures can be Used

Electrical conductivity probes typically measure in mS/cm (milliSiemens per centimeter). Salinity can also be reported as µS/cm (microSiemens per centimeter) or dS/m (desiSiemens per meter). Converting between units of Siemens is relatively simple, because while the units are different, the scale is the same. For instance,

1 mS/cm = 1 dS/m

1mS/cm = 1000 µS/cm

Occasionally older reports use the *mho* unit for electrical conductivity. A *mho* is the reciprocal of *ohm*, the unit of electrical resistance (and you thought chemists don't have a sense of humor).

1 mho/m = 1 mmho/cm = 1 mS/cm = 1 dS/m = 1000 µS/cm = 0.1 S/m

Be sure to pay attention to whether the denominator (bottom) of the fraction is in centimeters or meters!

In aquaponics and hydroponics, people sometimes use total dissolved solids (TDS) as an estimate of salinity, instead of electrical conductivity. However, TDS measures all dissolved solids in water, not just salt, so electrical conductivity is a more accurate measure of salinity.

Occasionally EC is used as an estimate of available nitrogen because it is usually in a salt form (e.g. potassium nitrate or ammonium nitrate). However, EC measures the accumulation of all dissolved minerals, regardless of whether they are nitrates, sodium, potassium, magnesium, calcium, or others. A high EC reading, therefore, may be due to high nitrates or high sodium, but the difference will be indiscernible. For this reason, we do not recommend using EC to estimate nitrogen availability.

Furthermore, it is recommended that distilled water be used for these tests because it has very low to no EC. If distilled water is not used, you must also take the EC of the water used into account as it will add to the EC of the test result. For instance, well water may have an EC of 0.20 dS/m, and the test result may show an EC of 1.20 dS/m. The actual EC is 1.0 dS/m, considering the well water EC. Also, soils will have a natural EC based on their texture (ratio of sand, silt and clay) due to several factors. Sandy soils tend to have a lower natural EC than clay soils. This must also be considered.

What the Measured EC Means for the Farm Depends on Test Method and Growing Media Used

Even when the test method and material are taken into account, recommendations vary on how to interpret salinity measurements (BCMA, 2015; BCMA, 2017; Sanchez, 2015; Kotuby-Amacher, Koenig, & Kitchen, 2000; Hanlon, 2015). Table 1 combines guidelines for growing media EC interpretation from the British Columbia Ministry of Agriculture (BCMA, 2015; BCMA, 2017) and recommendations for soil EC interpretation from Penn State University (Sanchez, 2015). We chose these guidelines because they are more recent and more conservative than other references.

However, take care in interpreting your EC results. Even published ranges shown in Table 1 are very broad. Practice performing these tests is essential for correct interpretation. Consistency in testing protocol, and recordkeeping are important, so trends can accurately be tracked. Finally, a laboratory soil analysis is the best way to know your soil mineral content and nutrient availability.

Given that, measuring soil salinity regularly and recordkeeping is a best management practice because it allows you to monitor for changes over time. If salinity measurements increase, you can assess why, and what remedial action to take. It is important to note that even the slightest difference in sample collection methods, or in the substrate- or soil-to-water ratios when testing for EC can make a large difference in readings. It is important to be very consistent when sampling and preparing the samples for EC analyses.

Table 1. Electrical conductivity interpretation recommendations for soilless growing media and soil used for long-term production. The pour through method is for containerized plants. The SME is the standard laboratory test.

Material	**Growing media[1]**			**Soil**	**Interpretation**
Method	1:2 media:water[1]	Saturated media extract (SME)[2]	Pour-through[2]	1:2 soil:water[3]	**These ranges are guidelines and not recommendations. Care should be taken in interpreting values**
	EC reading in mS/cm (or mmhos/cm)				
	<0.75	<0.6	< 0.5	< 0.40	**Low:** Should be acceptable for all crops, including seedlings
	0.76 to 1.25	0.6 to 2.0	0.5 to 2.5	0.41 to 0.80	**Normal:** Very salt-sensitive crops may lose some yield
	1.26 to 1.75	2.0 to 3.5	2.5 to 3.5	0.81 to 1.20	**Moderately high:** Salt-sensitive seedlings may be injured. Salt-sensitive crop yield restricted.
	1.76 to 2.25	3.5 to 4.5	NR	1.21 to 3.20	**Very high:** Seedlings likely damaged. Adult crops may exhibit damage symptoms: wilting, nutrient deficiency symptoms.
	>2.25	>4.5	>3.5	>3.2	**Extreme:** Most crop roots will be damaged and crops will lose yield beyond this point.

[1] BCMA (2015).
[2] BCMA (2017).
[3] Sanchez (2015).

If Salinity Measurements are High, Consider What Might be Causing It

The word "salt" is commonly thought of as table salt or sodium chloride. However, there are many kinds of minerals that are classified as salts which could cause high EC in a soil.

If a soil or growing medium EC is in the "moderately high," "very high," or "extreme range" in Table 1, consider what inputs might be causing that result.

- *Did you recently add lime, sulfur, or gypsum?* Lime and sulfur are commonly added to soil to modify the pH. Peat-based potting mixes also often contain lime to counteract the acidity of the peat. Adding these materials can temporarily increase EC measurements, particularly if they have not been well mixed into the soil or growing medium (E. A. Hanlon et al., 2017). However, these materials should not cause the kinds of root damage that other kinds of salts can cause.

- *Did you add fertilizer recently?* A moderate increase in EC from added fertilizer is normal, but too much fertilizer, especially if it is concentrated, can cause damage if it directly contacts plant roots.

- *Have you added any other soil amendments (compost, manure, coffee grounds, etc.)?*
  Compost and manure can be sources of valuable plant nutrients and sodium salts. Compost and manure composition can vary widely depending on the inputs and composting processes used. Adding large amounts of other amendments, such as coffee grounds, can also contribute salts, as well as cause other unexpected effects on plant growth (Ciesielczuk et al., 2017; Hardgrove & Livesley, 2016). Before purchasing a soil amendment, consider requesting or paying for a laboratory analysis including soluble salts, plant nutrients, and sodium. You should add any compost or other amendment with a high EC or soluble salts test result in small amounts. Amendments should not make up a large percentage of a growing medium.

- *Have you tested the irrigation water?* A farmer using high tunnels should get a water quality test, including pH and salinity, and alkalinity. Irrigation water can carry dissolved minerals which will accumulate over time, potentially increasing the salinity and pH of the soil. For more information on how to test irrigation water for production under cover, read *Irrigation Water for Greenhouse Production* by Will & Faust, 2010.

Supplement EC test results with observations of plant stress symptoms. Salt-stressed plants may exhibit stunted root growth, nutrient deficiency symptoms such as leaf purpling, or necrotic leaf margins. Symptoms like these, combined with high EC test results, suggest that leaching salts may be beneficial.

If EC test results are high and you have not recently added nitrogen, lime, sulfur, or gypsum, consider a laboratory nutrient analysis test that includes concentration of nitrogen and sodium. Note that some standard soil fertility tests do not report these concentrations, so check with the lab first.

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