Soil Salinity Measurement Trial

Can an ordinary, analog ohm/volt meter be used to assess soil salinity?

Abstracted from ECHO Technical Note # 84 by Dr. Bob Harter and Dr. Tim Motis

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Excess Salt and Crop Production

Salt buildup typically occurs in dry areas where evaporation exceeds precipitation. Over time, as water evaporates, the minerals left behind begin to accumulate. Plants need a certain amount of soluble salts, but when the salt content of soil water is greater than that of the water inside plant cells, the plant roots cannot absorb the soil water.

The degree of salinity at which yields decline depends on the crop. Quinoa (*Chenopodium quinoa*), for example, is quite tolerant of salinity, whereas many annual vegetable crops are much more sensitive. Farmers in salt-prone areas need to know the salinity of their soils.

Units of Measure

Electrical conductivity (EC) is widely used to estimate soil salinity. Pure water has few minerals, is a poor conductor of electricity, and thus has a very low EC. As the mineral content of a liquid increases, EC rises. Two identical ways to express EC are millimhos/cm (mmho/cm) and deci Siemens/m (dS/m).

Measuring Devices

There are hand-held meters that measure EC and/or total dissolved solids (TDS), with TDS shown in parts per million (ppm or mg/L). These meters can be purchased for under $50US; however, they are not always as available as a simple ohm/volt meter.

Hand-held TDS meter (left) and two analog ohm/volt meters (right).

An ECHO Florida Lab Study

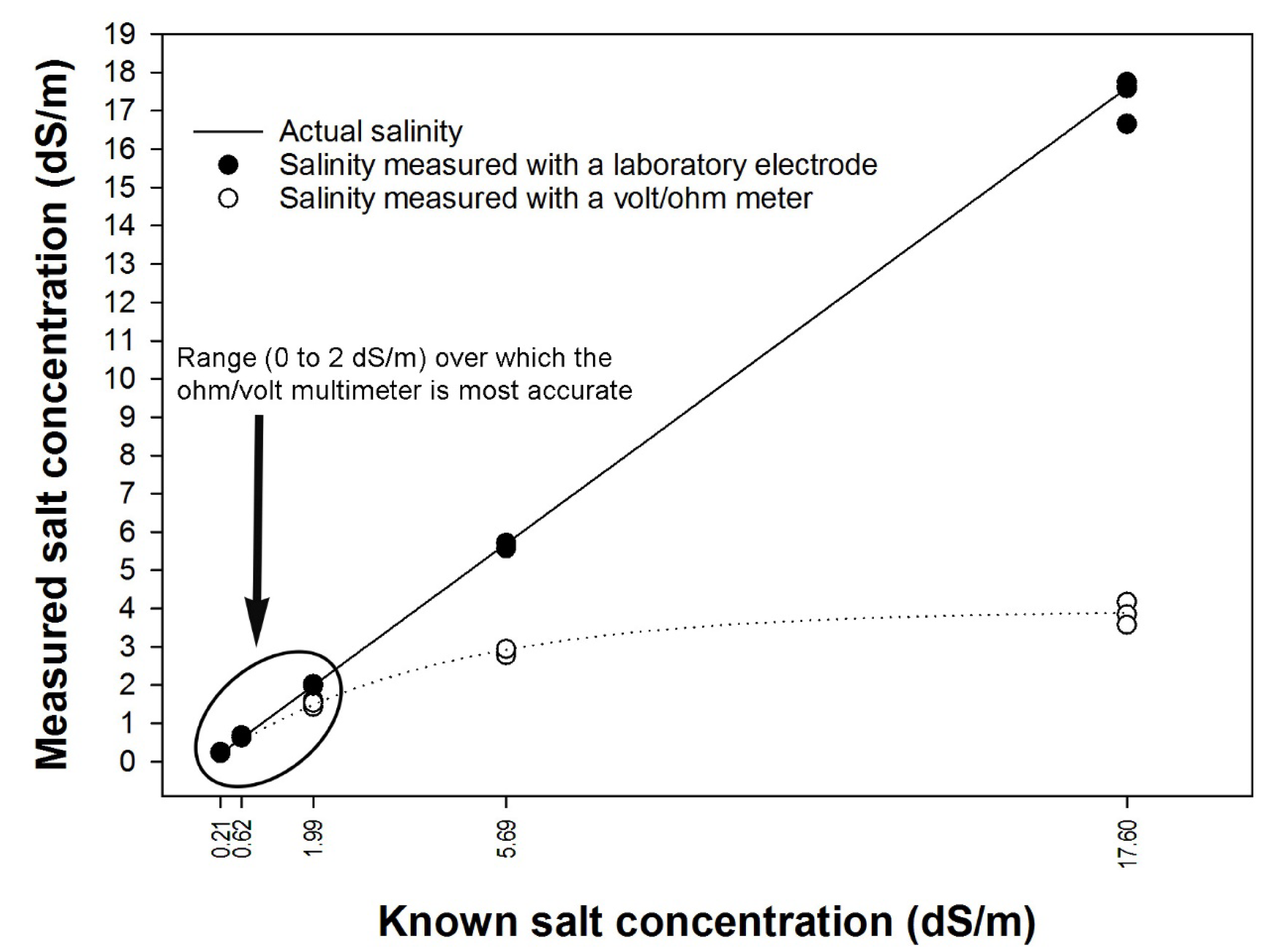
Objective: Determine the accuracy of an ohm/volt meter in measuring EC of a liquid with known salt concentration.

Materials: A Sunwa YX-360TRE-B multitester (larger of the two ohm meters shown above); a laboratory EC meter, and Morton's canning and pickling salt.

Procedure:

1) Calculated the number of grams of salt needed, per liter of deionized water, to create solutions of known salt concentrations (0.21, 0.62, 1.99, 5.69, and 17.60 dS/m).
2) For each concentration, weighed out the grams of salt to add to a 1-liter flask; flasks were brought to a volume of 1 liter with deionized water.
3) Poured each 1-liter stock solution into five beakers, using the ohm/volt meter and the lab EC meter to measure the salinity of the solution in each beaker.

Result: As the known concentration of salinity increased, the accuracy of the ohm/volt meter declined. A multimeter tends to underestimate salinity at higher salt concentrations due to the influence of direct current (used by the multimeter) on the ions in solution. By contrast, the EC meter uses alternating current. Nevertheless, up to about 2 dS/m, readings with the multimeter used in the experiment compared quite well to those taken with a laboratory EC meter.



Conclusion:

Yield reductions for most vegetable crops occur with salinity close to or under 2 dS/m. Results, therefore, showed that a multimeter can be used to give a rough idea of whether the salinity of a soil is low or high for most vegetables.

How to use an Ohm/Volt Multimeter

It works best to have an analog meter with an "X10" ohm setting. With such a meter, proceed as follows:

Prepare the meter for use

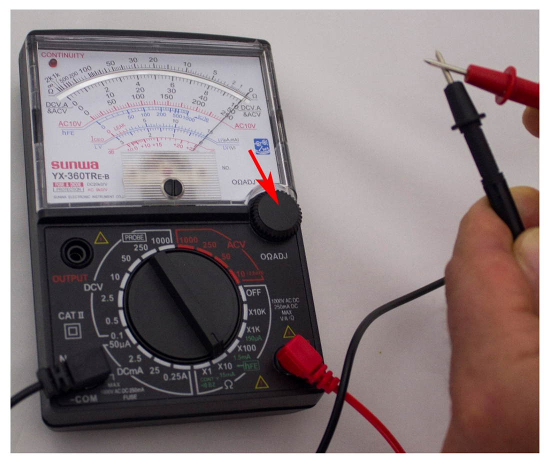
- Make sure the battery inside the meter is fresh, as accuracy is reduced with depleted batteries.
- With the meter off or not in use, ensure that the needle rests on the infinity mark (∞) on the left side of the scale. If it does not, use a flat screw driver to gently turn the zero adjuster screw to move the pointer to the infinity mark. This adjustment should not need to be made very often.
- Ensure that the probe leads are clean (no corrosion on the tips) and connect them to the meter. Do this by inserting the red lead into the positive socket on the meter, and the black lead into the negative (sometimes labeled as COM) socket.
- Set the meter to resistance, as shown by the symbol for ohms (Ω), turning the meter dial to X10 ohms.

Needle resting on infinity, with the zero adjuster indicated by a red arrow.

Probe leads connected, with the meter dial set at X10 ohms

Meter preparation continued…

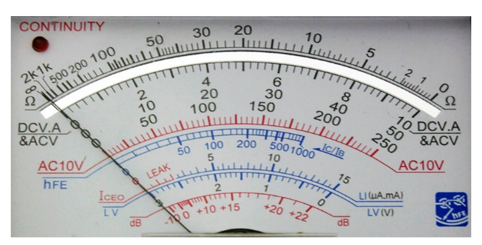
- Zero the meter by touching the tips of the red and black leads together. With the lead tips touching, turn the zero control knob until the needle rests on zero ohms (on the right side of the scale).



Needle set to zero by turning the zero control knob (red arrow) while touching the red and black lead tips together.

Take a reading

Place the probe tips about 1 cm apart in a saturated soil sample. This assumes that a soil sample has already been collected (see the bottom color bar of the poster for instructions). Record the number on the ohms scale, typically located at the top of the display, that the needle points to. A meter with a wide scale is easiest to read.



Reading being taken (left). Note the meter scale (top), with resistance indicated by the top-most band of numbers delineated by the Ω symbol.

Calculate the actual number of ohms being read

Because the meter is set at X10 ohms, the number of ohms that the needle rests on must be multiplied by 10 to calculate the actual number of ohms. For instance, if the needle rests on 100 ohms, the actual number of ohms is 1000 (100 X 10).

Interpret the actual number of ohms

Ohms is a measure of resistance to electricity. A non-salty soil will resist the flow of electrons (because there are few minerals to conduct electricity), so a reading near "1K" or "2K" indicates low salinity.

Most crop salinity tables are in a unit of conductivity (EC), so we need to convert the measured resistance (ohms) reading to an EC unit. First, calculate the inverse of the actual number of ohms, which gives us the number of "mhos." Continuing the example above, the inverse of 1000 ohms is 1/1000. Thus, 1000 ohms is equivalent to 0.001 mhos. Since the leads are held 1 cm apart, assume that the measurement is actually mhos/cm. Multiply mhos/cm by 1000 to convert to dS/m. A measurement of 0.001 mhos, then, is equivalent to 0.001 X 1000 or 1 dS/m. See the tables below for salt tolerances of vegetable crops, as well as a listing of EC units associated with ohms increments on a multimeter.

Table 1: Relative salt tolerance of vegetables (Maynard et al. 1997; Maas 1984).

Vegetable	Maximum Soil Salinity Without Yield Loss (Threshold) (dS/m)	Decrease in Yield at Soil Salinities Above the Threshold (% per dS/m)
Sensitive crops		
Bean	1.0	19
Carrot	1.0	14
Strawberry	1.0	33
Onion	1.2	16
Moderately sensitive		
Turnip	0.9	9
Radish	1.2	13
Lettuce	1.3	13
Pepper	1.5	14
Sweet potato	1.5	11
Broad bean	1.6	10
Corn	1.7	12
Potato	1.7	12
Cabbage	1.8	10
Celery	1.8	6
Spinach	2.0	8
Cucumber	2.5	13
Tomato	2.5	10
Broccoli	2.8	9
Squash, scallop	3.2	16
Moderately tolerant		
Beet	4.0	9
Squash, zucchini	4.7	9

Source: Knott's Handbook for Vegetable Growers

Table 2. Resistance units (ohms) on an analog ohm/volt meter converted to mhos (inverse of ohms) and electrical conductivity (EC) units (micro Siemens/cm [μS/cm] and deci Siemens/m [dS/m]) commonly used to indicate the salinity of irrigation water or soil. Note that 1 dS/m is the same as 1 millimho/cm.

Resistance		Conductivity			
Ohms shown on the meter scale (Ω)	Actual ohms at the X10 (Ω X 10) setting	Mhos/cm	EC (μS/cm)	EC (dS/m)	Vegetable tolerance*
3k (3000)	30000	0.0000333	33.3	0.03	Soil salinity range at which salt-sensitive crops like beans will grow with no yield loss
2k (2000)	20000	0.0000500	50.0	0.05	
1k (1000)	10000	0.0001000	100.0	0.10	
500	5000	0.0002000	200.0	0.20	
400	4000	0.0002500	250.0	0.25	
300	3000	0.0003333	333.3	0.33	
250	2500	0.0004000	400.0	0.40	
200	2000	0.0005000	500.0	0.50	
180	1800	0.0005556	555.6	0.56	
160	1600	0.0006250	625.0	0.63	
140	1400	0.0007143	714.3	0.71	
120	1200	0.0008333	833.3	0.83	
100	1000	0.0010000	1000.0	1.00	
90	900	0.0011111	1111.1	1.11	Soil salinity range at which moderately sensitive crops like tomato will grow with no yield loss.
80	800	0.0012500	1250.0	1.25	
70	700	0.0014286	1428.6	1.43	
60	600	0.0016667	1666.7	1.67	
50	500	0.0020000	2000.0	2.00	
40	400	0.0025000	2500.0	2.50	
30	300	0.0033333	3333.3	3.33	
20	200	0.0050000	5000.0	5.00	**
10	100	0.0100000	10000.0	10.00	
5	50	0.0200000	20000.0	20.00	

***See Table 1**

****Moderately tolerant crops such as beets and squash can tolerate up to 4.7 dS/m with no yield loss. Few vegetables would tolerate above 5 dS/m of soil salinity without at least some yield loss. Seawater has a salinity of over 40 dS/m.**

Salinity is probably minimal if the needle rests at the left end of the scale, near the infinity (∞) mark. If the needle rests at an ohms value of 50 or less (before multiplying by 10), salinity could be limiting for most vegetables shown in Table 1.

Other applications of salinity measuring devices

Even if your soil is not saline, there are other benefits of having an ohm or EC/TDS meter. You may want to test, for example, the salinity of your irrigation water. You could also assess the strength of soluble fertilizer, including that of manure tea, to make sure it is diluted enough to avoid salt injury to crop plants.

How to Take a Soil Sample to Measure Soil Salinity

Take soil from the depth at which the seed will be planted. Do not include any surface salt crust that might be present. In most "salty" soils, the sample will be loose, but crush any aggregates or clumps of clay. Place the soil in a clean, dry, non-metal (e.g. plastic, glass, or ceramic) container. Add salt-free water until you can see water shining on the surface, but not over the surface. Distilled water is best, but rainwater is acceptable. It may be necessary to add a bit more water after the soil has absorbed the initial moisture. You have created a saturated soil condition. After a short equilibration period – soluble salts do not take long to dissolve, so 10 minutes should be enough – measure the soil conductivity. NOTE: the sensor on a typical hand-held EC meter is not made for inserting directly into soil; if using one of these meters, mix 1 part soil with 2 parts water, pour the water through a filter (e.g., coffee filter paper), and then take the reading by placing the sensor probe into the resulting, clear liquid.