ARE YOU MEASURING ELECTRICAL CONDUCTIVITY OR TOTAL DISSOLVED SOLIDS?

Nowadays, cultivators are under pressure to produce high-quality plants while minimizing production costs and maximizing yields and profits. This can be achieved by having total control over the aerial environment and the rhizosphere. To properly control both environments, it is necessary to closely monitor crops, assess the value and execute the proper actions to maintain the right environment for the plant to reach its maximum genetic potential. One important input for crop culture is the management of crop fertility. In this article, we will discuss the use of Electrical Conductivity (EC) to measure the ions in a solution.

ELECTRICAL CONDUCTIVITY (EC) VS. TOTAL DISSOLVED SOLIDS (TDS)

Growers should frequently monitor the mineral content in the water, nutrient solution and the growing medium before and during the crop cycle. An easy way to evaluate this value is to know the EC of the nutrient solution, however sometimes a grower may respond with "282 ppm" or "450 ppm". Unfortunately, those values do not mean anything when we are trying to evaluate the mineral content in water, nutrient solution or growing medium. In a solution, the EC is the ability of the solution to transmit an electrical current, which is measured in units as µS/cm, mS/cm or dS/m. Total Dissolved Solids (TDS) is the weight of the solids that were in a solution after the water is evaporated; these units are measured in ppm or mg/l. Since the TDS is estimated by a gravimetric method, which is time consuming; this value can be obtained indirectly by measuring the EC of a solution. In the previous example, the cultivator's answer is in TDS, however this is inaccurate because the value can vary depending on the sensor conversion factor into EC. The conversion factors for 1 dS/m to ppm are between 0.4 and 1; the most common conversion factors are 0.5 and 0.7. The main difference between both factors is the amount of salts contained in the solution, thus the sensor might have to be adjusted during the crop cycle because the salt content increases as the plant grows. In general, well water has low mineral content (low EC) while a nutrient solution, which has all essential elements, has a higher EC. In contrast, distilled water or RO water will have an EC close to 0 dS/m, since all nutritive elements are removed. As a result, a concentrated nutrient solution will conduct more electricity, which means higher EC than a low-concentration nutrient solution.

Fig 1: Example of an EC measurement with a handheld meter using SME (saturated medium extract) of in-use growing medium sampled from a crop after several weeks. EC is measured to determine the concentration of salts. ***Source: Premier Tech***

TESTING WATER EC AND PH TO AVOID PROBLEMS

Knowing the EC and pH of the water, nutrient solution, drainage and other characteristics of the growing medium are important to avoid plant development and growth problems. The water EC can be used to evaluate its quality. For example, high EC values usually means high content of K, Na and Cl. The EC of the nutrient solution helps us to see if the injection rate or the fertilizer concentration is at the desired level. In most fertilizer labels, it is common to find the relationship between the content of ppm of N and its corresponding EC for a specific injection rate. In one hand, if the water quality is good, high EC means high nutrient concentration. On the other hand, a little difference in water and nutrient solution EC means low nutrient concentration. Therefore, by knowing the nutrient solution's EC, it is possible to estimate the concentration of essential elements. Another method is to measure the leachate or drainage EC to give us an idea of how much water the plant is using and if it is necessary to increase the percent drainage to avoid salt built up in the medium. Similarly, the medium EC and pH give us an idea of the salt content (including essential elements) in order to make a decision on watering frequency and if it is necessary to lower or increase the pH.

Fig 2: When measuring EC of in-use growing medium, select samples from multiple containers. Remove the upper ½ inch of growing medium and discard, since salts can concentrate at the surface and give inaccurate readings. Use core samples of media from container of same crop, and of same age, and blend together. For testing with the SME method (Saturated Medium Extract), add deionized or distilled water to blended sample and mix until surface of growing medium is glistening on surface, as shown in the picture above. Wait 1 hour, then take measurements with EC and pH meter placed into the 'mud'. Always calibrate meter before use. ***Source: Premier Tech***

WHAT IS THE ACTUAL NUTRIENT CONCENTRATION IN A NUTRIENT SOLUTION?

Let's do a quick calculation (Table 1). Based on recommendations, the cultivator needs to fertigate the crop with 20-10-20 peat lite fertilizer at a rate of 100 mg/l. The injector rate is set at 1:128 and in this case well water is used. The well water pH is 7.5 and the alkalinity ($CaCO_3$) is 150 ppm. By using 20-10-20 peat lite, the medium pH will decrease over time if the cultivator is using this fertilizer as the only source of nutrients. This is because this fertilizer has an acidic reaction. These are the results:

Table 1. Concentration of the essential elements in the nutrient solution.

	Concentration (mg/l or ppm)										
	N	**P**	**K**	**Ca**	**Mg**	**S**	**Fe**	**Mn**	**Zn**	**Cu**	**Mo**
Water	4	0	2	80	6	16	0	0	0	0	0
Fertilizer	100	0	0	120	0	0	1	0.5	0.5	0.2	0.1
Total	**104**	**0**	**2**	**200**	**6**	**16**	**1**	**0.5**	**0.5**	**0.2**	**0.1**

The well water EC is 0.5 dS/m, the fertilizer adds 0.6 dS/m to the well water. Therefore, the EC of the nutrient solution will be 1.1 dS/m (Table 2). For this example, we will use three sensors with different conversion factors:

Table 2. EC and TDS measurements from three different sensors.

	Well water EC (dS/m)	**Nutrient sol. EC (dS/m)**	**Conversion factor**	**Well water TDS (ppm)**	**Nutrient sol.**
TDS (ppm)					
Sensor 1	0.5	1.1	0.50	250	550
Sensor 2	0.5	1.1	0.64	320	704
Sensor 3	0.5	1.1	0.70	350	770

Based on this example, the use of EC is the same for all sensors. However, the TDS is different for each sensor depending on the conversion factor each sensor uses. If the cultivator is measuring TDS and he asks for an advice to see if the fertilizer application rate is enough, the answer could be one of the three values 550 ppm, 704 ppm or 770 ppm. However, if the cultivator says 1.1 dS/m, the technical advisor can relate the nutrient solution's EC with the EC that the fertilizers adds to the well water.

Measuring the EC and pH of a solution is a straight forward reading since the sensor is placed directly into the solution and it reads both values. To measure the EC and pH of the growing medium, the sample needs to be processed by using one of the three methods: Saturated Medium Extract (SME), 1:2 method or pour-though. To compare the EC readings of growing medium, it is necessary to know the methodology used, since each of these three methods have different values for the ideal ranges. For example, a value that is classified as heavy range for SME is classified as medium range for the Pour-Thru Method.

In conclusion, it is strongly recommended to use EC measurement since it is a universal method, compared to TDS which can vary for several reasons. TDS is helpful to give us an idea of the total ion concentration in a solution, but it does not give us the concentration of a particular element. Also, TDS is a calculated measurement based on the EC of the solution, the conversion factor of equipment used and the ion concentration of the solution. EC values give us a universal reading which makes it easy to compare results to known standards and to compare to laboratory methods.

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