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Why “Capillary Electrophoresis” May Become Your Two Favorite Words

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All plant growers need to pay close attention to the nutrients their crops are getting. But for CEA greenhouses, where margins are thin and water's gold, it's even more critical. You need maximum quality and yield from every food or pharmaceutical plant you grow in order to cover your high operating costs and still make a profit.

The award-winning CE-Line gives you an accurate measurement of your macro and micronutrient concentrations in less than an hour, rather than having to send it to an off-site laboratory or wait for an internal lab to conduct a test. As for its accuracy, independent laboratory testing (in collaboration with Wageningen University in the Netherlands) has proven a repeatability of 95%, meaning no more than 1 in 20 measurements may exceed a 5% divergence from stated values.

Right: CE-Line installed.

CE-Line was developed in the Netherlands by CE-Line International BV, a spin-off from The Sensor Factory, which designs and builds sensory equipment for dynamic, on-the-spot applications where processes occur, to avoid costly and time-wasting off-site analysis. Their sensors work with a continuous flow of material rather than in batch fashion. Dramm is the North American distributor of the technology and provided the technical details below.

How it works

The “CE” in the name comes from the principle of “capillary electrophoresis,” a separation technique widely used in analytical chemistry and biochemistry to measure ion concentrations in water samples. CE separates ions based on their mobility within a narrow (50 micron) capillary tube filled with an electrolyte solution. When a 20,000-volt electric current is applied across the capillary, ions within the sample migrate towards the oppositely charged electrode. As these ions traverse the capillary, they experience varying degrees of resistance based on their charge, size and shape. This results in different migration rates, effectively

separating the ions along the length of the capillary. As the separated ions pass through, they are measured by a detector that records their arrival times and intensities. This data provides precise information about the composition and concentration of ions such as ammonium, potassium, calcium and more within the sample.

Plug and play design

Installation of a CE-Line is simple: The unit gets plumbed directly into a bypass loop in your irrigation supply line and/or return line. The only setup requirements are a 0.5-micron filter, power and an internet connection. You can use CE-Line with any brand of environmental control/fertigation equipment.

The device opens a valve to draw water from the pipe and purges it through the system to ensure a representative sample. These samples can be collected every hour from as many as eight input sources on the supply or return side, providing a full analysis of all the major points in your irrigation system, allowing you to measure both the nutrients going to the plants and the level of uptake they are getting (based on the remaining ion content in the drain water).

Following each test, the unit performs an automated post-run cleaning procedure using sodium hydroxide, hydrochloric acid and water. This ensures reliability despite varying sample conditions, like pH or organic content, which can challenge CE's precision. The only human intervention required is the replacement of liquid reagents once a month (a monthly supply will give you 200 to 240 samples). The process, from sample collection to the end of cleaning, takes about an hour. Compare that to sending water samples to an off-site lab, which could take up to a week for the results to come back to you, making acting upon those results questionable at best.

What it can measure

The CE-Line measures a wide range of macro and micronutrients, including sodium (Na), ammonium (NH₄), potassium (K), sodium (Na), magnesium (Mg), calcium (Ca), chloride (Cl), nitrate (NO₃), sulfate (SO₄), bicarbonate (HCO₃), phosphate (PO₄), iron (Fe) and boron (B), with more micronutrients coming. Measurements are stored securely in the cloud and visible only to you, and has API (application programming interface) connections that enable integration with your climate control and nutrient injection systems.

Results are delivered to your computer via CE-Line's dashboard or via readout on your environmental control system's panel, and are expressed in mM (millimolar) on a graphical timeline, allowing you to easily see spikes or dips in the concentrations of each element so you or your grower can make any needed adjustments. Being able to see data points throughout the day lets you spot trends in nutrient fluctuations, allowing you to fine-tune and optimize fertigation to prevent problems and maximize yield. And while the system cannot yet provide autonomous control of your fertigation system (the "holy grail" of nutrition automation, we are told), that is because of limitations in the environmental controls, not in the CE-Line system. Expect that development to be forthcoming.

The benefits

The benefit of real-time nutrient data is the precise control of your fertilization and irrigation processes, preventing over-or under-dozing and optimizing nutrient delivery to your crop. You can compare and correlate

nutrient uptake with climate data like light, temperature, humidity and CO2 level, allowing you to optimize both nutrient delivery and the growing climate.

CE-Line data can also alert you to potential problems with your fertilizer injectors or drains, which could lead to improper feeding. This level of precision enhances crop yield, reduces waste and supports sustainable practices by minimizing nutrient discharge into the environment.

Though new to the market, CE-Line is already operating or being installed at some major production facilities around the world, producing tomatoes, peppers, strawberries, lettuce, herbs, cannabis and more. And while there are somewhat similar competitors on the market, those utilize ion sensors, which are less accurate and less reliable, and also miss some major nutrients.

What's it cost?

According to Dramm, the one-time cost of the CE-Line unit is \$49,000. Add \$2,000 to \$3,000 for the engineering, plumbing and filtration for each feed or return line from which you want to sample. The reagent chemicals will range from \$7,000 to \$13,000 per year, depending on how many samples you take. But what can you save? That's hard to estimate, but with the potential for higher yield (3-5%, they say) and increased crop quality and consistency, plus savings on fertilizer, not to mention reducing the risk of losing a crop due to a malfunction somewhere in your fertigation system, we suspect systems like CE-Line will become as common in CEA production facilities as environmental controls and energy curtains.