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FEATURES

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Staying Clean

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Commercial growers learn early in their careers to be vigilant in managing sanitation programs. Regardless of the production environment—field, greenhouse or vertical farm—every CEA production system requires an all-in commitment to establish good sanitation practices to discourage microbial enemies.

PACE® PLANT HEALTH ADVOCATES

The reality of sanitation

Elimination of microbes that cause plant diseases, those that cause human illnesses, and those that form biofilms and algae-supporting complexes comes with contradicting realities. By definition, elimination means zero, but quantifying this is nearly impossible due to limitations of sampling and analytical testing technologies.

Figure 1. Three treatments are shown, each consisting of three channels. Left channel group: No DDAC; Middle: 2 ppm DDAC pulse for two minutes twice per week; Right: 2 ppm DDAC pulse for five minutes twice per week.

That's the first reality: zero doesn't automatically mean zero. The opposing reality, the one most growers live with, is committing to managing microbial populations below threshold levels to minimize production losses, and ensure worker and consumer safety.

This hiccup is more challenging with human pathogens than plants and more concerning in food crop production. How much *E. coli*, Salmonella or Listeria is acceptable? Knee jerk says zero, but how does a grower ensure that every nook and cranny, every nutrient film channel, every hard surface that the crop contacts is completely free of pathogens? Unless your world is the sterile confines of a surgical operating room, chances are quite high that a "sterile" environment is not a reasonable, sustainable goal. Continually advancing research on this issue continues to generate better guidelines for growers to follow. This project is one such effort.

DDAC

Pace 49 offers a quaternary ammonium-based product line (UpTake Pro, KleenGrow) containing the active ingredient Didecyl dimethyl ammonium chloride known as DDAC. Older growers are familiar with “quats” as sanitizing agents and several products have been used by generations of horticulturists.

Figure 2. In this experiment it appears that after eight days the DDAC concentration had dropped below an inhibitory level to something low enough to stimulate crop growth.

These historical products were hard surface sanitizers only and limited in use to surfaces, including pots, benchtops and tools. Direct crop contact resulted in phytotoxicity. DDAC, a new, fourth-generation quat, is different from the earlier products and advanced in its features and uses. Perhaps the biggest difference in this generation of quat chemistry is it’s much less phytotoxic to crops, resulting in new uses for growers. The most impactful new use is direct application to plants.

Hydroponics’ unique challenge

What is it about a hydroponic production environment that poses a challenge that’s unique compared to traditional, substrate-based crop production? It’s the environment the crop’s root system calls home and the fact that, essentially, there’s hardly anything there.

During this project’s first experiments, labelled rates that are safe and effective for traditionally grown crops were phytotoxic when applied through recirculating hydroponic systems. In the absence of the substrate’s protective presence, the exposed roots were very sensitive to the sanitizing agent.

This wasn’t limited to DDAC treatment and its membrane-disruption mode of action. The oxidizer mode of action category of sanitizers also produced phytotoxicity at rates labelled for traditional substrate-based production. It quickly became clear that a hydroponic system presents a unique challenge resulting from the lack of protection, buffering or however else we describe its root zone environment.

Research

Pace has assembled a multi-university-private sector research team to investigate DDAC efficacy in hydroponic leafy green production systems. During the past eight years the team has focused on DDAC efficacy in hydroponic production of lettuce in nutrient film channel (NFT) systems.

Work done at Virginia Tech University included treating several sources of irrigation water with DDAC rates ranging from 1 to 8 ppm. Sterile water served as a control, and crop soil extract solution and recirculating reservoir solution were included. *Phytophthora nicotianae* served as the microbial target and as little as 2 ppm of DDAC reduced the levels of colony forming units (CFUs) to undetectable levels. And in the sterile water only 1 ppm of DDAC produced undetectable CFUs.

Private sector work with DDAC started with rates of 2 to 8 ppm and immediately determined that 2 ppm inhibited shoot fresh weight accumulation at harvest. The inhibition resulted from direct damage to the roots within hours of DDAC exposure. It was concluded that the unprotected roots were much more sensitive to the sanitizer than when the same roots were buffered by a growing mix.

Pulse vs. continuous exposure

Learning that the unprotected roots are more sensitive led to adjusting DDAC treatment to a pulse rather than continuous exposure. Shifting to this tactic has shown that a 2 ppm pulse of DDAC at a duration of five to 10 minutes and frequency of one to two treatments during a six-week lettuce crop cycle is safe with regard to the harvest criterion of shoot fresh weight.

Pulse safety vs. efficacy

The next step was to determine if pulse treatment that was dialed back to prevent root phytotoxicity is effective in managing plant pathogens, biofilm and algae. Figure 1 shows inner surfaces of nutrient film channels receiving DDAC pulse treatments with accompanying plants to confirm crop safety. Three treatments are shown, each consisting of three channels. Left channel group: No DDAC; Middle: 2 ppm DDAC pulse for two minutes twice per week; Right: 2 ppm DDAC pulse for five minutes twice per week.

The channels were covered during the experiment except for picture-taking sessions and algae development under vacant channel holes was monitored. In the picture, algae development (degree of green coloring) can be seen as inhibited to varying degrees by DDAC treatment; center and right treatments appear less green than control on left.

Returning to the earlier reality of zero not always meaning zero, the project's progress to date is suggesting that dialing back the sanitizer exposure to avoid phytotoxicity may come with less than complete control of microbial enemies. It's believed that some control is better than none and as the research continues new tactics with new efficacy options will be identified.

More than a sanitizer

Quaternary ammonium compounds offer other benefits that are leveraged in agriculture. DDAC is also a surfactant and useful in lowering surface tension in water across several settings. Irrigation, propagation mist and foliar spray solutions are several uses benefiting from surfactant activity.

An unexpected observation occurred in a recent nutrient film channel experiment that's adding another layer to the DDAC story. Pictured in Figure 2 are lettuce plants approaching harvest stage. The group of three channels on the right is the control treatment receiving no DDAC throughout the crop cycle. The three-channel group on the left received DDAC at the initial concentration of 2 ppm at the start of the experiment continuously circulating through the channels.

The plants in the picture were placed in the channels eight days after the experiment started and the picture was taken 28 days after placement. Most sanitizers show decreased concentration over time following a fixed initial charge. Reasons for declining concentration include direct consumption resulting from attacking microbes and other organic targets, volatilization of the sanitizer, degradation caused by sunlight (chlorine dioxide) or other reasons.

In this experiment it appears that after eight days the DDAC concentration had dropped below an inhibitory level to something low enough to stimulate crop growth. Plants added to the channels on earlier days of the

first week were inhibited, as expected, but the “week-after plants” growing larger was a surprise. Upcoming experiments will include DDAC rates below 2 ppm to investigate this observation. Stay tuned for more results.