BY PETER KONJOIAN

Advancements in Quat Chemistry

Read on for a summary of DDAC quaternary ammonium research in horticulture.

Quaternary ammonium compounds have a long and successful history in the horticulture industry. The most recent generation of quat chemistry includes the active ingredient didecyldimethylammonium chloride (DDAC). DDAC is offered as the commercial product KleenGrow from Pace 49 and is the subject of this research summary.

Sanitizing agents include various modes of action. One popular mode of action group is oxidizers and includes chlorine dioxide, ozone, and peroxide. DDAC's mode of action is membrane disruption, not oxidation, and as a result it offers opportunities that oxidizers do not. Using different products with different modes of action for algae, biofilm, and pathogen control is analogous to insect and disease control in that different mode of action products can be strategically used to offer thorough control. As the non oxidizer of the list, DDAC applications are growing as its potential is researched.

A diverse group of researchers has been active in DDAC studies in the U.S. and Canada, and this report will include work dating back to 2004. This section will summarize the group's work spanning bulb dips, foliar sprays, field soil drenches, plug tray treatment and hydroponic system treatment.

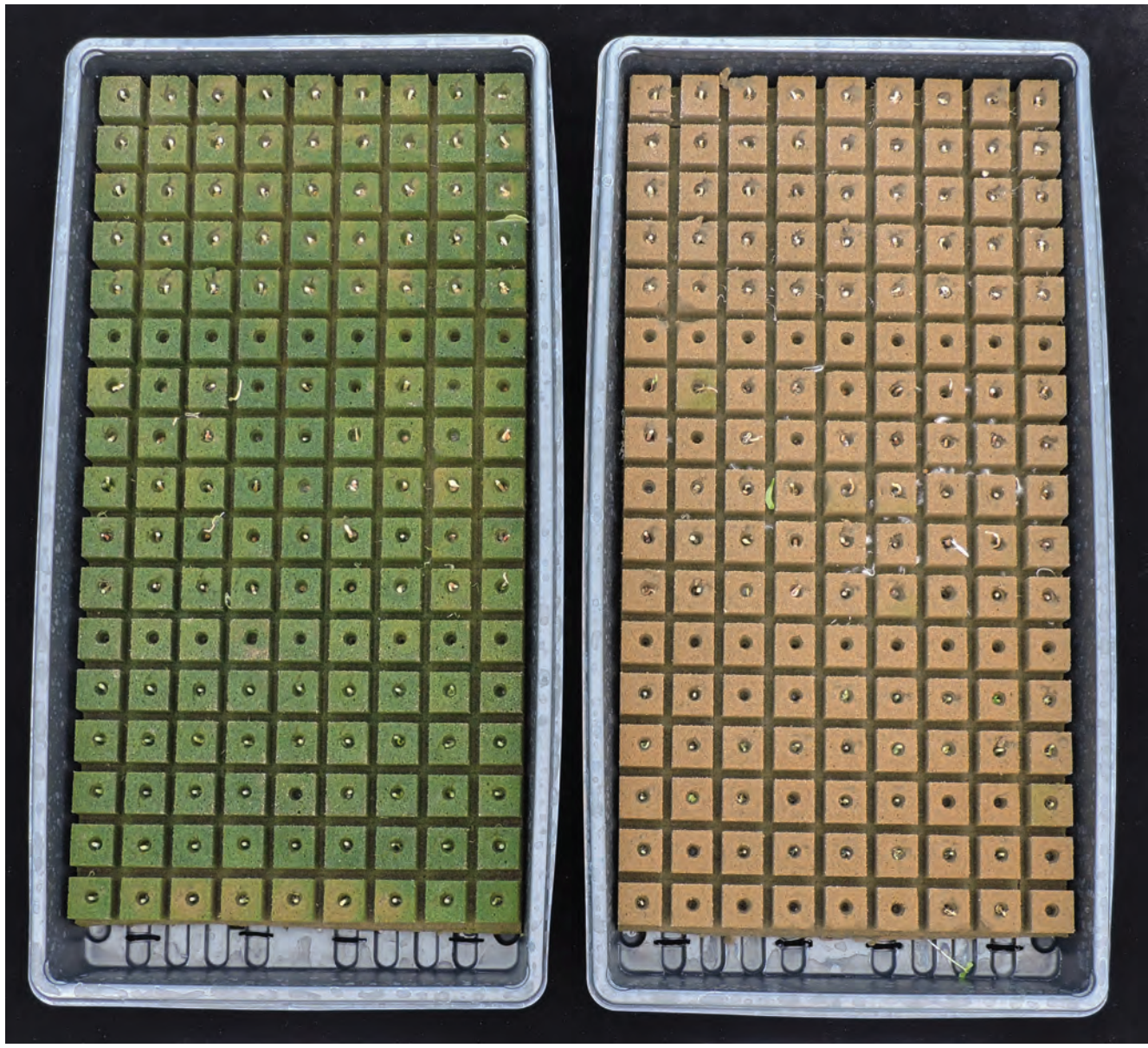

Figure 1. Control on left, 4-ppm DDAC on right during seed germination.

ANN CHASE

Chase Agricultural Consulting LLC

Ann's recent work with DDAC includes a 2018 study of a five-minute pre-plant bulb dip using caladium, gladiolus and lily bulbs. Two rates of DDAC were used; 1 and 2 ml/liter (approximately 100 and 200 ppm). The crops were grown to maturity and final grading showed no significant differences between treatments. Observations included that caladiums and lilies sprouted faster for the 100-ppm treatment than untreated controls and that lilies were slightly sensitive to the 200 ppm rate. Her results identified the rate of 100 ppm (1ml/liter) as the best performing treatment.

These experiments included sampling, plating and culturing the dip solution water following the dip and DDAC treatment eliminated bacterial and fungal spores in the water. This result may help eliminate the fear of cross contamination of bulbs via the dip solution. These results also provide initial guidance for applying the practice of dipping to unrooted cuttings prior to sticking in propagation media.

JANICE ELMHIRST

Elmhirst Diagnostics and Research

Prior to Chase's recent bulb dip work, Janice conducted research in 2004 in British

Columbia, Canada using DDAC as a pre-plant bulb dip for tulips and daffodils to treat contaminated bulbs. Her early work used the same KleenGrow rates of 100 and 200 ppm during the five-minute dip treatment and found both treatments significantly enhanced survival and reduced the incidence of Fusarium on daffodils. Final crop quality was effected by the 200-ppm rate as plants were stunted. A tulip cultivar sensitive to Fusarium and Penicillium responded positively to dip treatment at both concentrations as incidence of disease was significantly reduced.

Janice's work continued in 2006 with foliar and soil surface treatment of DDAC on a variety of potted crops in the greenhouse. KleenGrow was applied weekly at the rates of 0.13 and 0.25 oz/gal (approximately 75 and 150 ppm). Both rates resulted in rapid and significant reduction in surface algae with the higher rate offering more control. Plants treated with the higher rate, 150 ppm, showed signs of phytotoxicity.

STEVE JEFFERS

Clemson University

Steve is a professor and Extension specialist in plant pathology at Clemson. In 2016, he conducted research using DDAC to control Phytophtora nicotianae in field soil following pathogen introduction via infected plants during the prior year. A 5-liter volume soil drench at the rates of 1 and 2 oz/gal (585 and 1,170 ppm) was applied to each planting hole. His results showed that KleenGrow at both rates effectively mitigated the pathogen in the field.

KARL STEDDOM AND JAKE PRUITT

Texas A&M University

In 2015, Karl and Jake investigated KleenGrow injection into nursery irrigation water. A key conclusion from their work with Phytophthora is that each nursery's water can differ in terms of organic load and as a result a sanitizing product's most effective rate may be different based on the organic load being treated.

MIKE EVANS

Virginia Tech

Formerly at the University of Arkansas where this work was conducted, Mike's work in plug production investigated DDAC as a treatment for surface algae control. Research conducted in 2016 used lettuce germination and early seedling development in Oasis plug sheets as the subject system for DDAC application. Among his treatments were 2 and 4 ppm KleenGrow applied in the sub-irrigation solution during two flood cycles per day. Both rates of DDAC provided the best level of algae control compared to other

Figure 2. Lettuce grown in nutrient film channels with continuous DDAC treatment (left: untreated control, right: 4-ppm DDAC).

active ingredients included in the experiment.

Figure 1 shows two Oasis sheets, untreated control on the left and 4-ppm DDAC on the right. Up to and during seed germination surface algae developed freely on the surface of the control sheet but was significantly inhibited by DDAC treatment.

Concurrent to Mike's work with lettuce I began investigating DDAC use in hydroponic systems, specifically lettuce production in nutrient film channels. The first experiment examined continuous treatment using 2- and 4-ppm DDAC. Figure 2 shows lettuce plants halfway through their production cycle; untreated control on left, 4-ppm DDAC treated plant on right.

Even prior to taking this picture it was observed that the continuous contact with the naked roots was excessive given their exposed condition. In hindsight it makes sense that this environment is quite different from a potted plant or in-field setting where a peat lite growing mix or field soil offers buffer protection from the sanitizing agent. Close inspection of the treated root ball in the picture shows that new roots were active and trying to develop but were continuously being inhibited by treatment.

Subsequent to this experiment we chose to investigate a pulse treatment approach where DDAC was only circulated through the nutrient film channels for thirty minutes a day either daily, every other day, or weekly. Phytotoxicity occurred again but to a lesser degree and the next round of experiments will include shorter pulse time (five and 10 minutes vs. 30) and lower concentrations (0.5 and 1 vs. 2 and 4 ppm). The objective of this hydroponic work is to determine a dose of DDAC that is safe from a phytotoxicity perspective and then determine if that dose is high enough to offer control over unwanted microbes such as algae and pathogens.

RECURRING THEME; EFFICACY VS. PHYTOTOXICITY

Note the progression in this project from bulbs which are fairly resistant storage organs to whole plants in pots or field offering a buffered root environment to seed germination and seedling growth in an inert foam sheet to naked and exposed roots in a hydroponic system.

In addition to currently working with DDAC in my own research, I spent a decade researching chlorine dioxide as a sanitizing agent in the oxidizer category. Regardless of product (chlorine, chlorine dioxide, ozone, peroxide), oxidizers all follow the same theme of efficacy vs. phytotoxicity. Each requires us to understand that striking a balance between maximum efficacy vs. minimum phytotoxicity is a challenge. Too high a rate may be more effective but result in phyto while too low a rate may be safe but less effective.

Regardless of mode of action and chemistry of active ingredient, these sanitizing products share a common characteristic; they are applied to kill living organisms. The challenge we face is wanting and needing them to be selective in killing algae, pathogens, and biofilms without killing the crops being produced.

Bringing the various research results presented in this article together paints an encouraging picture of DDAC in a discussion of its potential. There appears to be a correlation between crop tolerance to or protection from the active ingredient. A bulb is a much more protected organ than a naked root system in a hydroponic setting. As such, it was shown to tolerate relatively high rates of DDAC treatment. A root system buffered, protected, by a potting mix or field soil is more tolerant to the sanitizing agent than a naked root system as well.

As we continue to gain experience researching sanitizing agents in potted and hydroponic environments, I believe dosing novel tactics that include but are not limited to pulse treatments rather than continuous exposure will offer benefits to sensitive crop situations. Our goal is to strike that balance between a sanitizing agent's potential to harm the crop vs. its potential to control unwanted microbes.

One characteristic of DDAC as a new generation quat compound is that it is significantly safer regarding phytotoxicity than earlier generation products. Those earlier quat products were not labelled for direct application to crops because of their phytotoxicity. Advancing quat chemistry has allowed us to take a giant step forward and add a complementary, non oxidizer, mode of action product to our sanitation tool box. gpn

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