The Use of DDAC (Quaternary Ammonium) in Hydroponic Systems

A multiyear research project shows encouraging results for DDAC use in hydroponic lettuce production.

By Peter Konjoian

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Figure 1

In this image from the first experiment, the left plant was untreated and the right plant was treated. Both 2 and 4 ppm caused inhibition as seen in the picture; however, that caused by 4 ppm was more severe than 2 ppm. Photos: Peter Konjoian

This article presents research results investigating the use of DDAC (Didecyl dimethyl ammonium chloride: KleenGrow, UpTake; Pace Chemicals) in hydroponic leafy green production.

Five experiments have been completed in nutrient film channels using 'Harmony' lettuce. Seeds were germinated in Oasis cells, young plants were transferred to nutrient film channels two weeks from sowing, and mature shoots were harvested four weeks after transfer. The nutrient solution contained 150 ppm nitrogen from a 13-2-13 soluble fertilizer formulation. Makeup solution was added regularly and the research took place in a greenhouse with 75°F/62°F day/night temperature set points.

The Phytotoxicity Challenge

Experiment 1 used continuous dosing of DDAC at concentrations of 2 and 4 ppm in the daily nutrient solution. One week after initiating treatment, phytotoxicity was observed. Neither concentration killed plants, but shoot stunting was severe after four weeks. Root inspection at harvest showed severe inhibition in treated plants with both 2 and 4 ppm causing similar inhibition. These results produced two conclusions: first, phytotoxicity occurred at the root level, which resulted in shoot stunting, and second, continuous exposure was excessive.

Pulse Dosing, Intermittent Exposure

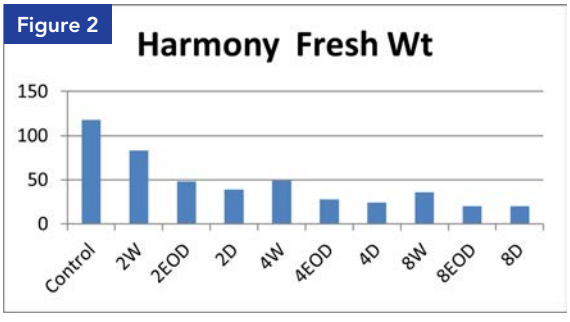
Experiment 2 replaced continuous exposure with a 30-minute pulse applied at three frequencies: daily, every other day, and weekly. Three concentrations were used: 2, 4, and 8 ppm and pulse treatments were made using clear water.

The pulse solution circulated through channels using dedicated reservoirs and pumps to ensure that the pulse solution did not blend with the daily nutrient solution. Each pulse treatment was followed by a 10-minute flush of regular nutrient solution drained to waste to minimize contamination of the daily reservoir.

Figure 2 shows shoot fresh weight at harvest (vertical axis in grams) for the three concentrations (2, 4, 8 ppm) and three pulse frequencies of weekly (W), every other day (EOD), and daily (D). Statistical analysis was not performed.

The left bar is the untreated control and to its immediate right is 2 ppm pulse applied weekly, every other day, and daily followed by 4 ppm and 8 ppm. Within each concentration fresh weight declined (phytotoxicity increased) as pulse frequency increased. Also, a concentration

Figure 2



This chart from the second experiment shows shoot fresh weight at harvest (vertical axis in grams) for the three concentrations (2, 4, 8 ppm) and three pulse frequencies of weekly (W), every other day (EOD), and daily (D). Graphics: Peter Konjoian

effect was observed as 4 and 8 ppm caused more inhibition than 2 ppm. While 2 ppm applied continuously in experiment 1 resulted in unacceptable inhibition of shoot growth, in experiment 2 pulsing this concentration for 30 minutes at a weekly interval was less damaging. A concentration of 2 ppm produced root mass similar to the control while 4 and 8 ppm produced progressively more root inhibition.

Figure 3

This image from the second experiment shows whole plants seven days after the first pulse treatment. The phytotoxicity did not kill plants, consistent with the first experiment, but stunted them significantly. Pictured from left to right; untreated control, 2 ppm weekly, 4 ppm weekly, and 8 ppm weekly.

Fine-tuning Pulse Parameters

Experiment 3 included the same concentrations of 2, 4, and 8 ppm and replaced 30 minutes of fixed pulse duration time with times of 5, 10, 15, 20, 25, and 30 minutes. A single pulse was used in this experiment for simplicity.

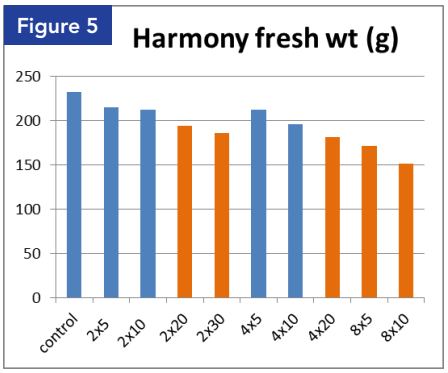
Figure 4 shows lettuce plants 16 days after the single pulse. The channels from bottom to top are control, 2, 4, and 8 ppm. Within each channel from left to right are pulse duration times of 5, 10, 15, 20, 25, and 30 minutes.

If a diagonal line is drawn from upper left to lower right, plants in the lower left group receiving lower concentration and shorter pulse duration performed more similarly to untreated plants as those in the upper right receiving higher concentration and longer pulse duration. Our conclusions: 2 ppm may be tolerable while 4 and 8 are unacceptable, and less than 30 minutes of pulse duration time may be tolerable.

Figure 4

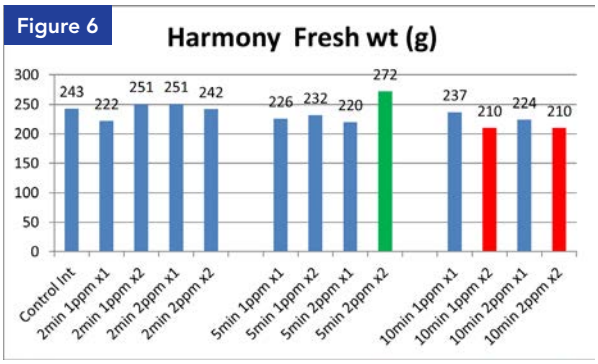
This image shows lettuce plants 16 days after the single pulse treatment in the third experiment. The four channels from bottom to top are control, 2, 4, and 8 ppm. Within each channel from left to right are pulse duration times of 5, 10, 15, 20, 25, and 30 minutes.

Figure 5



Shoot fresh weight averages from the fourth experiment are presented in the graph above. Treatment bars in blue were designated as acceptable and bars in red unacceptable. Two conclusions were drawn from this experiment; first, 8 ppm can be eliminated from future consideration and, second, a maximum pulse duration time of 10 minutes was chosen to advance.

Figure 6



A simplistic observation between the final two experiments is that eliminating 8 ppm and including 1 ppm resulted in fewer red (unacceptable) bars (seen in the fourth experiment) and more blue (acceptable) bars in the fifth experiment, as shown in the chart above. Additionally, the single green bar shows a treatment that produced higher fresh weight than the control, which may or may not be statistically significant but nonetheless intriguing.

The fourth experiment further refined pulse treatment concentration, duration, and frequency. Treatments included 2 ppm at 5, 10, 20, and 30 minutes, 4 ppm at 5, 10, and 20 minutes, and 8 ppm at 5 and 10 minutes. Essentially, treatments in the upper right of Figure 4 were eliminated. Additionally, pulse frequency was either a single pulse or two pulses applied one week apart.

Results are consistent in that higher concentration and longer pulse duration can be eliminated from future consideration. Based on the data, it is conclusive that 8 ppm can be eliminated from consideration, and, a maximum pulse duration time of 10 minutes advances.

The fifth and final experiment to date added 1 ppm for the first time after eliminating 8 ppm. Treatments included 1 and 2 ppm with pulse duration times of 2, 5, and 10 minutes and pulse frequency of 1 or 2 pulses, one week apart. This experiment added additional evidence supporting up to 2 ppm DDAC when applied as a weekly pulse of up to 10 minutes.

The Pulse Path Continues

Concluding, this multiyear project has produced encouraging results supporting DDAC use in hydroponic lettuce production. Laboratory research has shown DDAC efficacy in controlling microbes at concentrations reported in this report, and the greenhouse phase of determining pulse treatment efficacy in managing algae and biofilm is currently underway. GG