NCERA-101
Annual Station Report
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New Facilities and Equipment: None to report

Unique Plant Reponses: None to report

Accomplishment Summary: Pythium aphanadermatum is a devastating root disease organism to which spinach is particularly susceptible. This disease has prevented successful hydroponic spinach production in the United States. Ultraviolet radiation, sonication, filtration, and electrochemical treatment were evaluated to determine their efficacies in suppressing disease in continuous production for at least as long as required for baby-spinach to reach harvest (approximately two weeks after germination). Additionally, aeroponics production was contrasted to deep-pond production.

No conventional method worked in the deep-flow system. The method that worked was to reduce nutrient solution temperature to 20 C (68 F) and produce commercial-quality crops within 14 days. A surer method was to create sequential production ponds where plants are moved from one to a second part-way through the production cycle. The method is believed to work by taking advantage of the disease reproduction period, which appears to be approximately 15 days at 20 C. This method requires limited refrigeration capacity in an insulated deep-pond system of commercial size but does absolutely require supplemental lighting and daily light integral control to achieve sufficient productivity within the allowable production period before disease strikes, as it will.

A process based model of a tree seedling nursery was created to assist greenhouse energy management. Communication with Douglas-fir seedling growers indicated a lack of use of greenhouse-crop models in commercial seedling production. This model termed GUESS, Greenhouse Use of Energy & Seedling Simulator, integrates a lumped parameter dynamic heat and mass transfer model of the greenhouse envelope with a process based model of the crop growth allowing the simultaneous assessment of energy cost and crop health and growth. Hourly weather data and crop/greenhouse parameters are provided as inputs; and a profile of energy use, indoor climate, and crop production are returned as outputs.

Synthetic chelators are commonly used in hydroponic media to solubilize Fe; however, the fate of these chelators is unknown. The persistence of three synthetic chelators, ethylenediaminetetraacetate (EDTA), diethylenetriaminepentaacetate (DTPA), and ethylenediaminedisuccinate (EDDS) was studied in a bench-scale lettuce production system. The EDDS concentration decreased rapidly within 7 days, most likely due to biodegradation. EDTA and DTPA concentrations stayed steady throughout the experiments despite additions to maintain a constant volume and loss of chelator may have been due to either plant uptake or photodegradation of the chelator. Despite large differences in solution chemistry, the final shoot concentrations of Fe, Mn, Cu, and Zn were similar among chelator treatments, whereas root concentrations of these same elements were highly variable. We also measured the concentration of DTPA in a commercial lettuce production system and found highly variable concentrations.

Impact Statement: Cornell University has developed, tested, and proved a method to produce hydroponic baby spinach continuously with root zone temperature control that suppresses and slows the reproduction cycle of the disease without undue suppression of spinach growth. Continuous production of hydroponic spinach has not been successful in this country due to frequent devastation of the crop by the root rot disease, Pythium aphanadermatum. Local production, year-round, of fresh spinach has, thereby, been essentially impossible. Repeated experiments showed the method, keeping the root zone at 20C, was able to suppress disease outbreaks and even return a diseased production system to root and plant health.

Iron availability in hydroponic systems is frequently a problem due to the insolubility of iron in nutrient solutions. Chelators of various types are used to hold the iron in a form plant roots can access. Cornell University has shown that light is highly destructive of chelators, even with exposure to modest levels for less than half an hour. This result should lead to important hydroponic production protocol changes to keep the nutrient solution continuously in the dark. The discovery also suggests an advantage of deep-flow production systems compared to nutrient film or other hydroponic systems.

Published Written Work:

Albright, L.D., K.P. Ferentinos, I. Seginer, J.W. Ho and D. de Villiers. 2007. Systems and methods for providing optimal light-CO_2 combinations. United States Patent 7,184,846, February 27, 2007.

Mathieu, J., R. Linker, L. Levine, L. Albright, A.J. Both, R. Spanswick, R. Wheeler, E. Wheeler, D. de Villiers, R. Langhans. 2006. Evaluation of the Nicolet model for simulation of short-term hydroponic lettuce growth and nitrate uptake. Biosystems Engineering 95(3):323-337.

Seginer, I., L.D. Albright and I. Ioslovich. 2006. Improved strategies for a constant daily light integral in greenhouses. Biosystems Engineering 93(1):69-80

Shelford, T., D. de Villiers, R. Langhans and L. Albright. 2006. A comparison of three treatment systems for suppression of Pythium aphanadermatum in continuous production of hydroponic baby-leaf spinach. Paper No. 064020. ASABE, St., Joseph, MI. 8 pp.

Scientific and Outreach Oral Presentations: None to report