NCERA-101: Committee on Controlled Environment Technology and Use
2017 Station Report

Department of Bioresource Engineering, McGill University
Ste-Anne-de-Bellevue, Quebec, Canada H9X 3V9
Mark Lefsrud April 12, 2018

Impact Nugget

Research is continuing in the areas of plant growth in controlled environments: focusing on plant substrate, greenhouse heating using wood pellets, creating innovative greenhouse designs for crop production in extreme climates and investigating light emitting diodes on plant growth. We we are continuing our research on: 1) a soot particle removal and wood pellet furnace exhaust gas enrichment system for greenhouses 2) growing plants in porous concrete 3) a design for a northern greenhouse and 4) work on plant growth using LEDs.

Accomplishment Summaries

The Macdonald Campus of McGill University is researching means to use biomass for heat and carbon dioxide enrichment in controlled environments with a focus on greenhouses. The system combines an electrostatic chamber and a cyclone section that allow for extended operation of the traditional air filter. This last year we worked on developing technology to extend the operation of the electrostatic chamber and remove VOC that may be generated and present in the combustion gas. Stability of the system has been very good with up to 7 days of continuous operation possible with longer term testing required. We are continuing this research and are hoping to enter into an option agreement with an industry partner to build a commercial unit.

We are continuing our light emitting diode research. This project is to determine the proper wavelengths and ratios of light emitting diodes to maximize production. This research is ongoing, but we have begun to add in amber LEDs to the red and blue mixture with improved production of lettuce plants. We are expanding this research to include Arabidopsis and tomato plants and will be publishing these results this coming year.

We have continued to develop a cooling systems for a greenhouse called the NVAC, with test units build at campus, inside a greenhouse and at Barbados. The data collected from the NVAC is expected to be published this coming year.

The design of a northern greenhouse is continuing with further testing and improvements required. We have successfully grown a crop of lettuce and had fruit set on tomato plants inside the unit. We have extensive collaboration with northern partners and are hopeful that this research will result in a northern operation in the coming year.

We have begun testing on using porous concrete for plant growth. We tested the porous concrete using different concentrations of Hoagland's solution with the slag based porous concrete. The double Hoagland treatment porous concrete had similar dry mass values as the rockwool treatment. The radish in the double Hoagland treatment yielded a lower fresh mass with respect to rockwool (84.7%) but a higher dry mass than rockwool (125.4%). The nutrient absorption in the slag porous concrete treatments was observed to be different than the nutrient absorption in

the control rockwool treatment. The elevated EC and pH in the slag porous concrete treatments did not hinder the rate of germination and produced plants with lower water contents. The slag porous concrete proved phosphate adsorption and did create noticeable phosphorus deficiencies in the tomato plants grown. Similarly, nitrogen deficiencies were seen in radish plants in the Hoagland treatment. It is suggested that plant nutrient uptake is dependent per plant species and the ideal range of nutrient concentrations could have been located between the single and double strength Hoagland.

Impact statement

The Biomass Production Laboratory at McGill University has shown that plant growth on porous concrete is possible with very strong results growing plants at pH up to 9. We are working with our industry partners to refine this substrate technology and allow for it to reach commercial scale production. The results have shown that plants have a very strong ability to grow at elevated pH levels and with proper nutrient management can reach and surpass the yield on rockwool. We are working with our industry partners to develop applications of this material including architecture, coastal restoration and ecological locations in addition to horticultural applications.

Published Works

1. **Madadian, E.**, A.H. Akbarzadeh, V. Orsat. M. Lefsrud. 2017. Pelletized Composite Wood Fiber Mixed with Plastic as Advanced Solid Biofuels: Physico-Chemo-Mechanical Analysis. Biomass Valorization WAVE-D-17-00104R2.
2. **Madadian, E.**, **C. Crowe**. M. Lefsrud. 2017. Evaluation of Composite Fiber-Plastics Biomass Clinkering Under the Gasification Conditions. Journal of Cleaner Production 164:137-145.
3. **Madadian, E.,** V. Orsat, M. Lefsrud. 2017. Comparative study of temperature impact on air gasification of various types of biomass in a research- scale down-draft reactor. Energy and Fuels 31(4), 4045-4053.
4. **Madadian, E.,** A.H. Akbarzadeh, M. Lefsrud. 2017. Pelletized Composite Wood Fiber Mixed with Plastic as Advanced Solid Biofuels: Thermo-Chemical Analysis. Waste and Biomass Valorization. WAVE-D-16-00799.
5. **Austin, E**., **A. Malouin,** M. Lefsrud, A. Akbarzadeh.2017. Gaseous pollutants measured in enrichment flue-gas when subjected to a high temperature environment. ASABE Paper 1701047. Spokane, WA, July 16-19, 2017.
6. **Buelvas, R.,** V. Adamchuk, M. Lefsrud, **P. Tikasz**. 2017. Crop canopy measurement using laser and ultrasonic sensing integration. ASABE Paper 17001002. Spokane, WA, July 16-19, 2017.
7. **Knight, R.S**., M. Lefsrud. 2017. Automated nutrient sensing and recycling. ASABE Paper 1701607. Spokane, WA, July 16-19, 2017.
8. **Naznin, M.T**., M. Lefsrud, V. Gravel, B. Alsanius. 2017. Comparison of Red and Red with Blue LEDs on Lettuce Production and Antioxidant Accumulation. ISHS - International Symposium on Greener Cities for More Efficient Ecosystem Services in a Climate Changing World. Bologna, Italy on Sept. 12-15, 2017.

Oral Presentations

1. Lefsrud, M. 2017. Sustainable Solid Waste Management: Innovations and current researches- Sustainable Solid Waste Management (SuSWAM) 2017, Ste-Anne-de-Bellevue, QC June 29, 2017.
2. Lefsrud, M. 2017. Pushing the Limits of Urban Agriculture – Improving the Efficiency of Urban Farms, Canadian Association for Food Studies / Congress 2017 The Next 150, Toronto, Ontario, May 27-June 2.
3. Lefsrud, M. 2017. Urban Agriculture, UBC Chemical Engineering, Vancouver, BC, March 6, 2017.
4. Lefsrud, M. 2017. Will the world run out of food? McGill Alumni. Telus Spark, Calgary, AB, February 28, 2017.
5. Lefsrud, M. 2017. Will the world run out of food? McGill Alumni. UBC Robson Square, Vancouver, BC, February 28, 2017.
6. **Naznin, M.T.,** M. Lefsrud, V. Gravel and B. W. Alsanius. 2017. Comparison of Red and Red with Blue LEDs on Lettuce Production and Antioxidant Accumulation. ISHS 2017-Bologna, Italy, Sept 12-15, 2017.
7. **Tikasz, P**., M. Lefsrud. 2017. Automation of water pumps in ebb and flow hydroponic systems. Paper 17-021. NABEC Annual Meeting Groton, CT, July 30-Aug 2, 2017.
8. **Knight, R.,** M. Lefsrud. 2017. Automated Nutrient Sensing and Recycling. Paper 1701609. ASABE Annual Meeting Spokane, WA, July 17-19, 2017.
9. **McCartney, L**., M. Lefsrud. 2017. The natural ventilation augmented cooling (NVAC) greenhouse: a greenhouse design for tropical and hot climates. Paper 1700974. ASABE Annual Meeting Spokane, WA, July 17-19, 2017.
10. **Austin, E**., L., **A. Malouin**, M.Lefsrud, A. Akbarzadeh. 2017. Gaseous Pollutants Measured in Enrichment Flue-Gas With A Focus on Ethylene. Paper 1701047. ASABE Annual Meeting Spokane, WA, July 17-19, 2017.

Other relevant accomplishments and activities.

Nothing to report.