NCERA-101: Committee on Controlled Environment Technology and Use
2013 Station Report

Department of Bioresource Engineering, McGill University
Ste-Anne-de-Bellevue, Quebec, Canada H9X 3V9
Mark Lefsrud April 12, 2014

Impact Nugget

We have been researching in two target areas: plant growth in controlled environments focusing on identifying the potential of greenhouse heating using wood pellets and investigating light emitting diodes for plant production. We have filed three provisional patents: 1) a wood pellet furnace exhaust gas enrichment system for greenhouses, 2) a design for a tropical greenhouse design and 3) a northern Canadian greenhouse design. We are working with Urban Barns on an improved LED lighting system for urban agricultural hydroponic lettuce production and in addition have completed a rainwater harvesting system for greenhouse irrigation.

Accomplishment Summaries

The Macdonald Campus of McGill University is continuing its research into controlled environments with work on the impact of biofuel heating systems with a focus on greenhouse heating using wood pellets with carbon dioxide utilization. The greenhouse heating research has resulted in the filing of a US provisional patent for the use of the exhaust gas from a wood pellet furnace to heat and use the CO_2 for improved production in the greenhouse. We are continuing this research and are working on design improvements to develop a commercial unit.

We are continuing our light emitting diodes research with industry collaboration from Urban Barns a company specializing in urban agriculture food production (lettuce and other leafy greens). This project is to determine the proper wavelengths and ratios of light emitting diodes to maximize production. This research is ongoing but has already resulted it a published paper confirming intercanopy lighting as an improved lighting system when compared to overhead LED or HPS systems. This research also found that at a 5:1 (red to blue) ratio of LED lights resulted in the maximum fruit production for greenhouse tomatoes but also led to an occurrence of powdery mildew on these plants prior to others as well as increased branching from the fruiting clusters of the plants.

We have begun the design and tests on two different greenhouses specifically a greenhouse designed for the tropics that uses water misting to create a natural ventilation loop and a northern greenhouse that maximizes natural solar light with supplemental LED lighting. Both of these designs are in the early stages of the patent process and full scale prototypes are projected to be built in the coming year.

Impact statement

The biomass heating group at McGill University has been trying to identify methods to use both the heat from combustion and the carbon dioxide. A major challenge of this work is the numerous other gases and particulates that are produced during the combustion process (CO, ethylene, SOx, NOx,) and remove these gases before injection into the greenhouse. Through the use of a gasifier we have been able to significantly reduce these gases to levels acceptable for direct injection into the greenhouse. Scale-up testing of the gasifier is ongoing to empirically support this conclusion.

Light emitting diodes have a strong potential to replace all supplemental lighting system in greenhouses and growth chambers. Our research was able to show this and that supplemental lighting with an intercanopy LED array and a HPS lighting system resulted in statistically identical plant production, when compared to 5:1 and 19:1 (red to blue) LED interlighting LEDs both at 120umol/m2/sec.

Published Works

1. Dion, L.M., M. Lefsrud, V. Orsat. 2013. Biomass gasification and syngas combustion for greenhouse CO_2 enrichment. BioResources. 8(2): 1520-1538.
2. Islam, S., M. Lefsrud, J. Adamowski, B. Bissonnette, A. Busgang. 2013. Design, Construction and Operation of a Demonstration Rainwater Harvesting System for Greenhouse Irrigation at McGill University, Canada, HortTech 23(2):220-226.
3. Bruce Coulman, B., A. Dalai, E. Heaton, C. Perez Lee, M. Lefsrud, D. Levin, P.G. Lemaux, David Neale, S. P. Shoemaker, J. Singh, D. L. Smith, and J.K. Whalen. 2013. Developments in Crops and Management Systems to Improve Lignocellulosic Feedstock Production. BIOFPR 7(5):582-601.

Oral Presentations

1. Harvest and Processing for Combustion. 2013. 42nd Canadian Science Writers Association Conference, McGill University, Montreal QC, June 7, 2013.
2. Roy, Y., M. Lefsrud, F. Filion, J. Bouchard, Q. Nguyen, L. Dion, A. Glover. 2013. Biomass Combustion for Greenhouse Carbon Dioxide Enrichment. ASABE Paper 1577923. Kansas City, MO, July 21-24, 2013.
3. Daiz, J.A.., G. Clark, M. Lefsrud. 2013. Building a finite element model for a natural ventilation greenhouse. ASABE Paper 1593098. Kansas City, MO, July 21-24, 2013.
4. Islam, S., M. Lefsrud, J. Adamoski, A. Busgang, B. Bissonnette. 2013. Design, Construction and Operation of a Demonstration Rainwater Harvesting System for Greenhouse Irrigation at McGill University, Canada. ASABE Paper 1554865. Kansas City, MO, July 21-24, 2013.
5. Daiev, K., M. Lefsrud. 2013. Increased Plant Production with Narrow Spectrum LED's. ASABE Paper 1554860. Kansas City, MO, July 21-24, 2013.
6. McCartney, L., M. Lefsrud. 2013. Natural Ventilation Augment Cooling (NVAC) Greenhouse. ASABE Paper 1554861. Kansas City, MO, July 21-24, 2013.
7. Naznin, M.T., M. Lefsrud, Y. Kitaya, T. Shibuya, H. Hirai and R. Endo. 2013. Integrated culture of garlic and Tilapia fish source of protein and medicinal compound Ajoene. ISHS International Symposium on Medicinal Plants and Natural Products. Montreal June 17-19, 2013.

8. Madadian, E., M. Lefsrud, C.Perez Lee, Y. Roy. Bioenergy Production: The Potential of Using Biomass Gasification. ICCE Ottawa, Canada. Sept 9-11, 2013.

Other relevant accomplishments and activities.

The successful results from the application of a number of grants we will allow us to continue our research for the upcoming years in LED lighting of tomato, proteomic expression and measurement of Arabidopsis, and also continued research on wood pellet greenhouse heating.