NCERA-101: Committee on Controlled Environment Technology and Use
2012 Station Report

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Impact Nugget

We have been researching in two target areas with the first focusing on identifying the potential of greenhouse heating using wood pellets and the second investigating light emitting diodes for plant production. Projects were completed in both areas with the construction and testing of a wood pellet furnace and a full greenhouse scale LED supplemental lighting experiment on hydroponic tomato.

Accomplishment Summaries

The Macdonald Campus of McGill University is focusing research on the improved energy efficiency of controlled environments. Specifically, a research project aims to determine the potential of biofuel heating systems using wood pellets on carbon dioxide utilization. The greenhouse heating research is comparing a wood pellet furnace (Caddy Altern; SBI, St-Augustin-de-Desmaures, Quebec) to a propane CO_2 enrichment system (CD-ELECTRA-12-LP; Greenair, Gresham, Oregon). The first step consisted of evaluating the quality of the exhaust gas and develop methods to scrub this flue gas in order to use the carbon dioxide for greenhouse enrichment. We developed a system able to filter, heat and catalyze the exhaust gas. Our initial results were very positive with over 97% CO removal and a significant decrease in SO_x and NO_x levels inside the exhaust gas. We have subsequently reduced the particle levels and further reduced the NO_x levels to below the Health Canada Indoor Air Quality Guidelines.

The research on light emitting diodes is investigating the impact that wavelength has on plant production on both individual plants and on a full tomato greenhouse experiment comparing LEDs to high pressure sodium (HPS) bulbs. Tomato plants were grown for over 120 days using 16hr of supplemental lighting. The experiment compared red to blue LED ratios of 5:1, 10:1 and 19:1 at 3 different intensity levels. Production of the LED treatments out performing both the HPS and the control (no supplemental lighting). However, a major issue that needs to be addressed is the method of light measurement when using LED lights, since LED are focused point light sources, small changes in orientation and location can result in major differences in irradiance measurement.

Impact statement

Biomass heating at McGill University has been trying to identify methods to use the heat and carbon dioxide produced during combustion. A major challenge of this work is to eliminate the numerous toxic compounds (CO, ethylene, SOx, NOx, and particulates) mixed with CO_2 that are produced during the combustion process. Through the use of a filtering system and catalyst, we

have significantly reduced the production of these gases to levels acceptable for direct injection into the greenhouse. Scale-up testing of the filtering system will be completed 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 that supplemental lighting with a LED array resulted in more biomass production than HPS system.

Our laboratory has shown that wood pellet heating and carbon dioxide enrichment is possible in a greenhouse and the addition of LED lighting can improve the production of tomato plants. Using a wood heating system can significantly reduce the heating costs and carbon dioxide enrichment cost for a greenhouse, specifically in the Quebec and Northeast US region. Likewise, the LED technology is very encouraging by reducing electricity costs and improving the final crop yields.

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. Martineau, V., M. Lefsrud, M. T. Naznin, D.A. Kopsell. 2012. Comparison of light emitting diode and high pressure sodium light treatments for hydroponics growth of Boston lettuce. HortScience 47(4):477-482.
3. 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 In Press.

Oral Presentations

- Deram, P., M. Lefsrud. 2012. LED lighting for greenhouse tomato production. ASABE, Dallas, TX, July 30- Aug 1, 2012.
- Naznin, M.T., M. Lefsrud, J. Gagne, M. Schwalb, B. Bissonnette. 2012. Determination of the effect of different wavelengths of LED on plant photosynthesis. ASABE, Dallas, TX, July 30- Aug 1, 2012.
- M. T. Naznin, M. Lefsrud, J. Gagne, M. Schwalb, B. Bissonnette. Different wavelengths of LED light affect on plant photosynthesis, ASHS Miami, FL, July 31 – Aug 3, 2012.
- Dev, S., G. Clark, M. Lefsrud, P. Adewale, J. Diaz Martinez. 2012. Finite element modeling and simulation of a natural ventilation greenhouse. NABEC-CSBE 2012 Orillia, ON.

Other relevant accomplishments and activities

We built a prototype tropical greenhouse that uses an evaporative cooling system able to produce a force air system (augmenting natural convection) inside the greenhouse. This design has great potential to reduce the energy costs associated with greenhouse cooling. Our laboratory has also installed a rainwater collection system to supply water to the nearby greenhouse without using municipal water.