Comparison of Two Cooling and Dehumidifying Methods for a Semi-Closed Organic Tomato Greenhouse.

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Background:

Two non-traditional methods of cooling and dehumidification have been tested to control excess humidity and high temperatures in a semi-closed greenhouse using cold water withdrawals from a saturated water table. The main objectives were to reduce greenhouse air humidity by limiting air exchanges with the outside climate and to increase carbon dioxide levels in the greenhouse in order to stimulate photosynthesis. The first studied method was a cold water fan coil system, where greenhouse air is cooled through a coil on which the water vapour condensates. The second method studied was a cold water curtain technology installed above the crop rows, forcing warm humid air to condensate on the cold-water curtain thus generating a free convection air movement within the greenhouse. These two methods were compared with traditional dehumidifying and cooling methods.

Project Overview:

The total cooling power capacity varied with the systems input conditions (temperature and relative humidity (RH) of greenhouse air and the temperature of the water table). The cooling capacity ranged between 125 and 600 W m^{-2}. The lowest capacity was observed when the ground water temperature was 12ºC and the greenhouse climate conditions were 18ºC and 85% RH. The maximum cooling capacity was observed when the temperature of the ground water was at 6ºC and the greenhouse climate conditions were 31ºC and 80% RH. In order to evaluate the effect of the system on the greenhouse climate a comparison of 3 typical days with similar weather conditions was performed. The water curtain, the fan coil technology and the traditional method were able to maintain set relative humidity and temperature climate conditions in the greenhouse. The water curtain and the fan coil technology were able to maintain high carbon dioxide levels (up to 1000 µL L^{-1}) in the greenhouse by maintaining closed roofs. With the traditional method, the carbon dioxide concentration did not exceed 400 µL L^{-1}, because the roofs needed to be open when high radiation levels were observed. Based on our initial results, the fan coil technology was selected to pursue our study because of its simplicity of use. Another typical day showed that the fan coil technology allowed the removal of water vapour generated by the crop. Based on average plant transpiration of 2.7 L m^{-2} (Turcotte, 2005), the 225 m^{-2} greenhouse generated a total of 607 kg of water vapour. During this day, the fan coil technology was able to condensate 607 kg of water vapour from the air.

Conclusions:

Our results showed that the two non-traditional methods allow the maintaining of desired climate conditions and CO_2 levels in a greenhouse. When using the fan coil technology on typical sunny day, the equilibrium between the transpiration of the plants and the condensation of the coil was possible. The upcoming trials will focus on system optimization and crop response over a yearly production cycle.

Acknowledgments: This research was funded through Canada's Organic Science Cluster, which, in turn, was funded by the Canadian Agri-Science Clusters Initiative of Agriculture and Agri-Food Canada's Growing Forward Policy Framework and its industry partners, Les Serres Jardins-Nature and L'Abri Végétal.