THE NORTHERN TOMATO

A HOT TOPIC IN A COLD CLIMATE

By Gwen O'Reilly

Conventional and organic vegetable production systems in Canada have many differences, but they share one major constraint: winter. Our less than tropical climate has fuelled the growth of commercial greenhouse production for vegetables such as tomatoes, peppers, cucumbers and lettuce.

Tomatoes comprise the largest share of Canadian greenhouse production. In some provinces, 90% of all tomatoes are grown in greenhouses[1]—perhaps because many consumers just aren't content to make do with salsa and canned tomatoes all winter. Conventional greenhouse production is now a significant and growing part of the agricultural sector, accounting for $2.5-billion of general farm value.[2] The demand for organic and regionally grown food is increasing by 15–25% annually, with 75–85% of the Canadian supply of organic products being imported.[3] It follows that organic producers in Canada are moving towards year-round production of warm weather crops.

But, that's where it gets tricky for organic producers who want to venture into an industry dominated by conventional agriculture. Small or passive greenhouses, like high tunnels and hoophouses, regulate the build-up of heat and moisture by venting to the outside air—unfortunately, this is not an efficient option in year-round operations. Large-scale commercial greenhouses are kept closed to control temperature, humidity and carbon dioxide levels (plants need CO_2 to photosynthesize and grow). These greenhouses need mechanized systems to heat, cool, dehumidify and provide additional lighting for tropical crops like tomatoes. Year-round greenhouse production is thus a highly energy intensive effort—one that consumes 12% of the energy used for agricultural production in Canada, and releases 2 million tonnes of CO_2 (literally, "greenhouse gases") into the atmosphere as a result.[4] The greenhouse industry, including organic producers, also produces effluent from nutrient solutions that can pollute water bodies and groundwater.[5] All together, this means that your February tomato is expensive in more ways than one.

Tomato plants growing in coco coir on the left and in organic soil on the right.

Research is underway to create greenhouse systems that are energy efficient and environmentally benign. Rising energy costs have already resulted in innovations among conventional growers such as thermal screens, better insulation, sophisticated temperature regulation and new structural designs. Organic Science Cluster (OSC) researchers are taking these a step further, looking at geothermal, biomass, and other sources for heat, cooling and dehumidification, as well as recycling, natural capture or remediation of greenhouse effluent.

Heating a translucent structure in winter is one thing (tomatoes don't do well below 16°C); but a closed greenhouse environment presents additional challenges for organic growers. Unlike conventional producers who usually use hydroponic systems, organic growers must grow their plants in a soil-based medium [see page 52 for details on organic potting mixes]. Soil increases humidity and adds the challenge of regulating populations of macro- and micro-organisms, including bacteria, fungi and insects. Fertilizer or nutrient solutions can cause salt to build up in the growing media (if recycled), or potential groundwater pollution if released.[6]

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Heating, cooling and dehumidifying: No sweat

OSC researchers in Quebec are evaluating two non-traditional cooling and dehumidifying methods in organic closed greenhouses. One is a geothermal cold water fan system, where warm, moist greenhouse air is blown through a coil cooled by groundwater. The air is cooled and moisture condenses during passage across the coil.

The second method carries the intriguing description of "water droplet curtain," also called an "open water to air heat exchanger." This consists of nozzles that spray fine curtains of cold mist at the roof (hot part) of the greenhouse, between rows of plants, to conduct heat and condense moisture in the air. A rain shower on a hot day has a similar effect. The falling water accumulates airborne heat and humidity. The water then collects on the greenhouse floor and is returned to an outside reservoir, where it is cooled before recirculation.

Preliminary tests show that both the geothermal water fan and a droplet curtain can cool and dehumidify as effectively as a venting system. They have the additional advantages of:

1) preventing the heat loss that could occur in a vented greenhouse, and

2) increasing the level of carbon dioxide.[7]

Heat capture systems can help regulate night-time temperatures. Water can be circulated during the day through hot areas in the greenhouse to absorb solar radiation, and then stored in an insulated tank for recirculation after the sun goes down.[8]

Nutrient management: Too much of a good thing

Fertilization in organic greenhouses involves the use of compost, kelp meal, or concentrated, reclaimed substances such as crab, shrimp or feather meal. Organic fertilizer run-off (which may contain high concentrations of nitrate, phosphate and other nutrients) has the same negative effect on groundwater as that from chemically derived compounds. What goes in must come out, so the Organic Science Cluster researchers are:

1) investigating ways to reduce the nutrient load in greenhouse effluent by adjusting fertilizer rates and timing to better match the needs of the plants, and

2) examining recirculation and remediation of greenhouse effluent.

OSC researchers Drs. Martine Dorais and Valérie Gravel and colleagues examined the impact of recirculation of effluents on tomatoes. The plants were grown in various soil media over three years. Crop yields were high in spite of increasing salinization (mineral salt build-up) in the growing media.[9] The researchers surmise that the salinization may have ultimately affected the total biomass of the tomato plants, but not yield.[6]

These OSC scientists are also assessing the use of constructed wetlands and passive bioreactors to capture excess nutrients. A constructed wetland is like a human-made swamp—waste water is circulated through gravel beds planted with species such as cattail, rush and iris. This can be established within or outside of the greenhouse (but wetlands don't work when frozen). The plants and microorganisms in the wetland take up and help break down excess nutrients and some toxic compounds. The resulting run-off is cleaner and can be released into natural watercourses without negative environmental impacts.[5]

Not only nutrients build up in effluent—pathogens and phytotoxins do as well, leading OSC scientists to examine whether artificial wetlands inoculated with biochar and 'passive bioreactors' can eliminate these additional problems.[10, 11] Biochar—charcoal made from burning woodchips, tree bark and other biomass—is the latest thing in amendments. As a soil amendment, biochar may increase microbial activity and nutrient exchange. Biochar is also used to filter impurities, including excess nutrients and pathogens, from effluent. OSC studies show that these techniques are more than 99.99% effective in removing Fusarium and Pythium pathogens from greenhouse effluent.[12]

Passive bioreactors more closely resemble a septic tank than a wetland, and are typically used to treat mine drainage. They use a combination of ecological (microbial) and geochemical reactions to remove metals from effluent and buffer its acidity. Plants in these systems add organic matter and stimulate microbial activity, but are not the main uptake mechanism. Once established, bioreactors are self-sustaining and can function for years with minimal intervention.

Let there be light

One significant issue for northern growers is supplemental lighting—short winter days do not a red tomato make. Fruiting vegetables require longer photoperiods to flower and develop a crop. Year-round, or even extended season production means adding lighting. OSC researchers led by Drs. Steeve Pépin and Martine Dorais compared the effect of supplemental lighting in both organic and conventional greenhouses, and found that there was no significant difference between organic and conventional tomato yields.[13]

Extended season production means adding lighting.

High-intensity high-pressure sodium lamps can contribute heat as well as light to the greenhouse, and the researchers are experimenting with novel ways to use the lights more efficiently. For example, they are evaluating the potential for using lighting within the crop canopy, instead of, or along with, above-canopy lighting.

Other established techniques involve using photoperiodic lighting, where supplemental lighting is used to bracket daylight hours to extend photoperiods when days are short. Supplemental lighting can also be used to interrupt darkness for a few hours, to achieve a similar effect. For significant energy savings, lighting can be cycled on and off every half hour for 6–10 minutes during the photoperiod. Higher intensity lighting can also be used in limited and targeted time periods, for example when a crop is young. Increased light produces better growth in young plants versus old, and since seedlings are usually grown at high density, there is less area to light.[14]

OSC researchers are not only testing new technologies, they are also quantifying the environmental impact of organic greenhouse production. Dorais and her team evaluated the environmental footprint of closed-loop, Northern organic tomato greenhouse production. They evaluated everything from raw materials extraction to the farm gate, including infrastructure and equipment, climate control, waste management, fertilizers, pesticides and packaging. Compared to a similar conventional operation, the organic system showed significantly less environmental impact in all categories, with the exception of greenhouse structures and packaging. The use of wood biomass as a renewable energy source for heating reduced the CO_2 footprint of one kilogram of tomatoes by almost seven times the rate of conventional production. The fertilizer assessment done for the organic crop also showed significantly lower environmental impact in all categories, most notably eutrophication (surface water effects of fertilizer run-off).[15]

Researchers continue to look for better ways to produce Northern organic tomatoes year round. However, these organically grown, February tomatoes are still more infrastructure- and energy-expensive than garden-grown, vine-ripened love apples. Until we all learn to survive on bottled, canned and dried tomatoes throughout the winter, Canadian growers can use

OSC's homegrown solutions to reduce the environmental cost of winter tomatoes, and hopefully capture a slice of this juicy market as a result.

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Photos: Linda Gaudreau (pg. 48), Martine Dorais (pg. 49)

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