Greenhouse climate control systems

Summary

To meet the specific greenhouse climate-control requirements of small and medium-sized companies, the Institut de Technologie Agro-Alimentaire de St. Hyacinthe approached two manufacturers of specialised electronic controllers in the agricultural sector: Systèmes Electroniques Monitrol Inc. and Thevco Inc. The accuracy of the devices' temperature sensors meets greenhouse specifications. For an annual crop requiring day temperatures of 20°C and night temperatures of 18°C, the potential savings for both devices are estimated at 12.5%. The average cost of the Monitrol system is CAD 1,200, while the Thevco system costs CAD 800. Payback periods are 38 and 25 months, respectively.

Highlights

- Low investment costs
- Energy savings of 12.5%
- Accommodates small to medium greenhouses

Thevco controller at the Institut de Technologie Agro-Alimentaire de St. Hyacinthe.
**Aim of the Project**

Climate control is vitally important to the operation of greenhouses. New, specialised, electronic climate control systems have become available on the market. From an energy efficiency point of view, significant savings in heating costs are possible with these systems. Two control systems, one manufactured by Systèmes Électroniques Monitrol Inc. (Figure 1) and one by Thevco Inc., were tested at the Institut de Technologie Agro-Alimentaire de St. Hyacinthe to verify that they are capable of meeting the environmental control requirements of small- (500-2,000 m²) and medium-sized (2,000-10,000 m²) greenhouse complexes and whether they control the environment in a more energy-efficient manner than conventional thermostats. The control of day and night temperatures and the accuracy of the readings are essential characteristics for any climate control system.

**The Principle**

The main properties of the two control systems include several features. Both the Monitrol and the Thevco system control greenhouse temperatures by using heating facilities, thermal curtains, and fans. Moreover, both units possess an internal clock for the control of day- and night-temperature setpoints. The Monitrol system also uses its internal clock to control temperature setpoints for the DIF, a climate control method in which the ambient temperature is lowered by a few degrees for a while before sunrise and then returned to the daily setpoint. The Monitrol device also regulates greenhouse humidity, using a combination of heating and ventilation. Additional features of the Monitrol system include a data collection module and a communication interface for the adjustment and display of remote control setpoints.

**The Situation**

The accuracy of the controllers were evaluated, along with their reaction time to changes in temperature. A 21X data collection system was installed together with the controllers. A mercury thermometer, as well as an electronic thermometer, were used in addition to the 21X system to evaluate the time lag with respect to changes in temperature.

Between 6°C and 43°C, Monitrol’s temperature sensors are accurate to +0.2 and -0.7°C. The controller displays the temperature in increments of 0.5°C. For temperatures between 10°C and 40°C, the moisture sensors give humidity readings accurate to ±3% between humidity levels of 40% and 70% (±5% for the rest of the temperature range). Thevco’s temperature sensors are accurate to ±0.2°C between 0°C and 70°C and the controllers display the temperature in increments of 0.1°C.

The Monitrol system’s reaction time is estimated at 1 to 3 minutes. This slow reaction time is not a real problem, because in most cases heating operations in greenhouses are on a cycle of approx. 15 minutes. Natural ventilation operations are more delicate, because they require more rapid control of cooling equipment to limit temperature drops near the crop. The Monitrol sensor generally underestimates the actual temperature by 2°C. This situation is critical, because the controller provides signals to the climate control equipment that result in slightly higher temperatures than required. Warming the greenhouse by
1°C more than the desired temperature results in additional annual heating expenditures of 5%. For the company concerned, this represents an additional CAD 450 on the total heating bill for the winter period (December to March). It is therefore essential to verify the precision of the temperature sensors periodically after they have been installed. In greenhouses, the critical zone within which humidity must be monitored lies between 80% and 100%. In the case of high humidity (>70%), the accuracy of the sensor exceeds 5%. So far, this system has been reliable. The controller meets the requirements of companies that need to control greenhouse humidity closely or are interested in data collection.

The reaction time of the Thevco controller’s sensor varies between 30 and 60 seconds. Rapid interventions are therefore possible during natural ventilation operations. The Thevco sensor overestimates the actual temperature by 0.3°C to 1°C. The accuracy and reaction time of the sensors are very acceptable for greenhouses and the system is reliable. Although not as elaborate as the Monitrol model, this controller is an interesting option for companies that do not need to exert close control over greenhouse humidity.

It is recommended that a ventilated box be used for both control systems, thus eliminating the boundary limit around the sensor and protecting it from sunlight, giving a more representative reading. It is also suggested that the accuracy of temperature and humidity sensors is verified at the time of installation.

The Companies
Monitrol Électronique Inc. was founded in 1987 to design and develop high-technology products for the electronic control of environmental conditions in agricultural buildings. The company operates primarily in the area of intensive animal production.

Thevco Inc. specialises in developing and manufacturing electronic ventilation and heating regulators for farm buildings.

Economics
Adjusting greenhouse temperatures at night is undoubtedly the most cost-effective option. Lowering temperatures at night by 2°C results in savings of 7% for a company producing all year round. For a company producing between March and August, lowering the temperature by 2°C at night results in 11% savings.

The accuracy of temperature control is another factor to consider from an energy efficiency point of view. The use of conventional thermometers results in slight elevated temperature setpoints to ensure a minimum temperature. Using accurate temperature control, the actual temperature in the greenhouse can be kept at a lower value. The difference is estimated at 1°C, resulting in savings of 5.5% annually.

The cost effectiveness of the control system depends on the area covered by the device, the production period, and the installation costs. As Table 1 shows, the Monitrol system’s installation costs amount to CAD 1,200, which is relatively high because of the inclusion of additional options (humidity control, data collection module, and communications interface). The Thevco unit costs CAD 800. Both controllers produce annual energy savings of approx. 12.5%. For a control area with annual heating costs of CAD 3,000, the payback period is 38 months for the Monitrol controller and 25 months for the Thevco unit.

Table 1: Annual savings for a day/night temperature setpoint of 20/18°C.

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<tr>
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<th>Monitrol</th>
<th>Thevco</th>
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</thead>
<tbody>
<tr>
<td>Estimated potential savings*</td>
<td>12.5%</td>
<td>12.5%</td>
</tr>
<tr>
<td>Average cost of system</td>
<td>CAD 1,200</td>
<td>CAD 800</td>
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<tr>
<td>Payback period**</td>
<td>3.2 years</td>
<td>2.1 years</td>
</tr>
</tbody>
</table>

*Estimated savings from day/night setpoints (7%) and from temperature accuracy (5.5%).
** For a greenhouse with annual heating costs of CAD 3,000.
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