

Temperature strategy in greenhouses: some common pitfalls

*Elly Nederhoff & Bert Houter
CropHouse Ltd, New Zealand*

Elly@CropHouse.co.nz

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Temperature control is responsible for a major part of the energy consumption in a greenhouse. Heating and venting for temperature control seems simple, but it can easily go wrong, wasting valuable energy. This article shows the basics and some common pitfalls of temperature control.

Heating & venting periods

The principles of temperature control are similar in most computer brands, based on settings for heating and venting (cooling). When the greenhouse temperature is below the heating line (or heating 'setpoint'), heating is activated. If it is at or above the venting line (or setpoint), the vents start opening. All systems have at least two periods (day and night) with a transition or 'ramp' between the periods. Most computer brands offer more periods: four, six or even endless. The extra periods can be used for instance for pre-night, early morning, etc. Period start times can be set by the grower.

Settings & graphs

Usually there are the following settings: heating temperature, venting (or cooling) temperature, period start times and ramps. The ramps indicate the speed of transition, for instance from night temperature to day temperature. The ramp can be indicated in hours per degree, or as duration.

A great number of settings can be required, especially if there are more compartments, and more than two periods in a day. It is hard to oversee all settings, so mistakes are easily made. Most climate control computers don't give an overview, but they can make a graph of the two temperature control lines. It is worthwhile to study this graph carefully.

Look especially at what happened outside work hours: the period of about 14 hours when few people are on site. It covers the two rampings when things are most likely to go wrong, as well as the night when the energy consumption peaks. Check out every morning what has happened overnight with heating and venting lines, pipe temperature, vent opening, greenhouse air temperature and humidity. Correct the settings if needed. Then the next day check if control has improved. Regular adjustment of settings can be needed due to fluctuations in weather conditions.

Cross-overs

Figure 1 shows an example of heating and venting lines with correct timing and ramps. This is the simplest situation with only two periods (day and night) and two ramps. The correct setting for temperature control is with the heating line below the venting line. The alternative, or 'cross-over', will lead to concurrent heating and venting, or heating-with-vents-open. This wastes a lot of energy. Figure 2 shows two unintentional cross-overs of about 90 minutes each at about 5 - 7 am and 5 - 8 pm.

Cross-overs may be done deliberately for humidity control in some periods, but that should be governed by humidity control rather than temperature control. Cross-overs can happen by mistake in temperature control, and often go unnoticed.

Heating temperature rises too fast

A ramp is the speed of transition from one temperature level to another. If the heating temperature setpoint gradually rises, the heating system will heat up and the greenhouse temperature will follow soon after. If the ramp is very steep, indeed the heating pipes and the greenhouse air temperature do rise very quickly too. The problem is that the plants can't follow so quickly; especially the fruits lag behind in temperature because of their mass. In **Figure 3** at around 7 am the plants are about 2 °C colder than the air, which is equivalent to 10% higher relative humidity. This poses a risk of condensation especially on the fruit and stems, and therefore a risk of mould and diseases.

Figure 5 shows the correct way of ramping in the morning, which leads to an acceptable difference between air and plant temperature, and therefore less risk of condensation and diseases. The recommended ramp for heating temperature is 45 - 60 minutes for every °C.

Heating temperature rises too late

On a bright morning, the sun has more heating power than the heating pipes. So the sun can heat up the greenhouse very rapidly. A fast temperature rise is not good, as discussed above, because it leads to condensation particularly on fruit. The trick to avoid this is to slowly pre-heat the greenhouse and the crop, so that they are warm by the time the sun comes out. Timing is critical. **Figure 4** shows what happens if ramping starts too late. The sun heats the air temperature very fast, but the plants can't follow so quickly. Between 9 and 11 am the plant are about 3 °C colder than the air, causing 15% higher relative humidity near the fruit. Condensation and fungal infection are likely to happen. The recommendation is to start rising in time, aiming to be at day temperature before or at sun rise. If the difference between night and day temperature is 3 °C, ramping takes 135 - 180 minutes (3 hours), so ramping has to start early. **Figure 5** shows the correct way of ramping up in the morning.

Poor timing from day to night temperature

When the sun loses power at the end of the day, the heating system comes in automatically to maintain the required greenhouse temperature, which is still day temperature. This costs energy. Very often this happens shortly before the temperature ramps down to the pre-night or night temperature. If the greenhouse temperature then exceeds the venting line (**Figure 6**), the vents open automatically. What happens is that first the heating pipes warm up and subsequently the vents open. See **Figure 6**. The heat boost just before dropping to the night regime is an unnecessary use of energy. This is a very common mistake.

The way to avoid this is by earlier ramping down the heating line, and later ramping down the venting temperature. **Figure 7** shows the correct way of ramping down, and avoiding the unnecessary energy loss.

Summery

Temperature control by heating and venting requires a number of settings. All systems have at least a day and night period, while most systems have more periods. The grower chooses the temperature level and the start time for each period, as well as the 'ramping' in the transitions between periods. Mistakes are easily made. Some recommendations:

- Check the graph of heating and venting lines every day
- Also check the pipe temperature, vent opening, temperature and humidity
- Avoid cross-over of heating & venting
- Increase the heating temperature slowly: 45 - 60 minutes per °C
- Reach day-time temperature before or at sun rise
- Don't give a heat boost just before dropping to the night temperature

A good temperature control strategy saves enormous amounts of energy and improves crop production and quality.

Energy in greenhouses - part 41

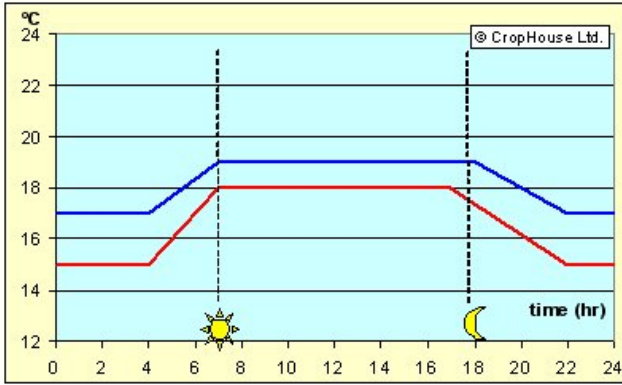


Fig. 1 Temperature control with two period.

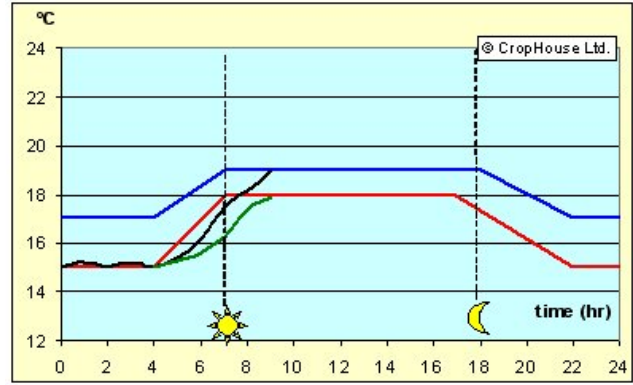


Fig. 5 Correct ramping in heating line.

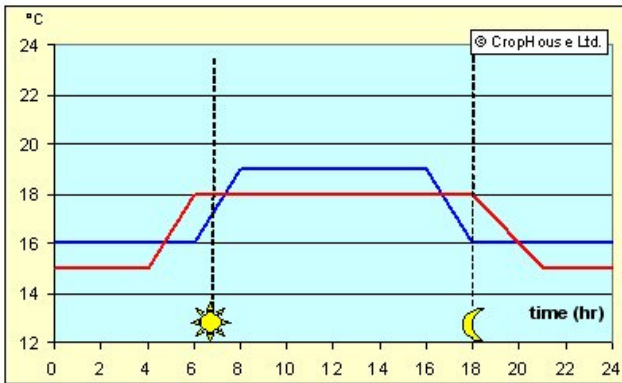


Fig. 2 Temperature lines with accidental cross-overs.

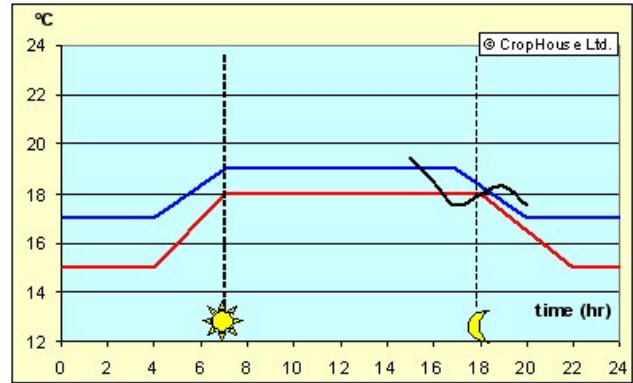


Fig. 6 Wrong timing late afternoon.

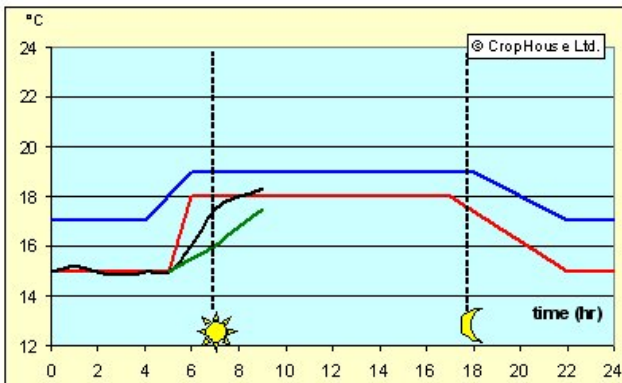


Fig. 3 Too steep ramp in heating line.

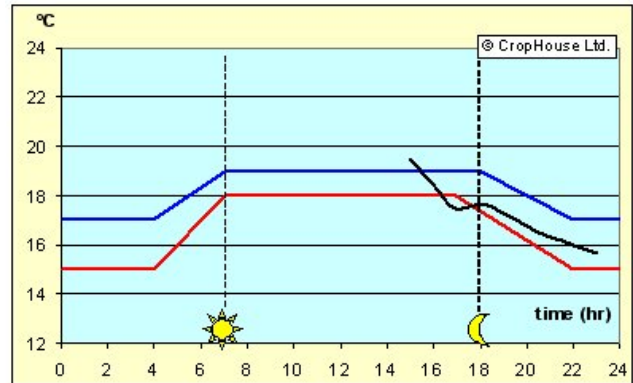


Fig. 7 Correct timing late afternoon.

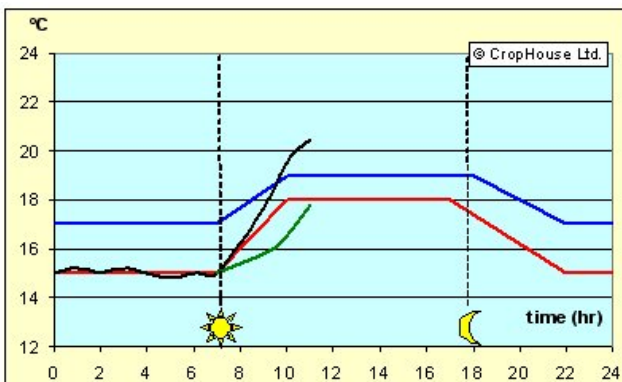


Fig. 4 Too late ramping in heating line.

