

Energy-wise greenhouse control

Elly Nederhoff

CropHouse Ltd, New Zealand

Elly@CropHouse.co.nz

Published in the Grower 58(10), 2003, p. 56-57

Modern greenhouses are controlled by advanced climate control computers. By choosing the settings in the computer software, the grower determines the growing conditions for the plant, as well as the energy consumption. Many modern greenhouse control programmes offer special features for energy conservation. The reality is that many greenhouse growers don't know much about optimal settings, and hardly ever use energy-wise options. Energy conservation starts with learning more about greenhouse climate control. This article describes some of the very basic facts of climate control in greenhouses with pipe heating. Future articles will look into specific features such as reducing minimum pipe temperature, control based on crop temperature, and so-called temperature integration.

Computer settings

The software in advanced control computers offers a wide host of settings. The software and the settings together form the control strategy. After the grower has keyed in the settings, the computer calculates the set points for temperature, air humidity, CO₂ concentration for any time of the day. The computer also arranges that signals are sent out to steer the heating, venting, CO₂ supply, and other devices such as heat storage, screens, fogging, misting, roof sprinklers, fans and more. Most programmes distinguish between different parts of the day, usually day and night. Some programmes allow splitting the day in up to six parts, enabling the grower to choose special settings for instance for pre-day, sun-rise, day, sun-set, pre-night and night. This is important since the control actions required at sun-rise are totally different from those at mid-day, for example. The huge number of settings enables perfect control, but also unwillingly increases the complexity of the control programmes.

Reason of temperature settings

It is important to understand why certain control actions are taken, and then to determine the optimal settings. Many growers use minimum pipe temperature or minimum ventilation, without analysing what it does. As an example, we look at settings for temperature control, i.e. settings for heating and venting.

The first reason for temperature control is to create optimal growing conditions for the plants. At night the temperature must be moderate: too high night temperature would exhaust the plants and would prohibit fruit set. During the day, plants take up CO₂ and produce sugars (the process is called photosynthesis, the sugars are called assimilates). Photosynthesis depends on the radiation: more assimilates are produced at higher light levels. It is important that the extra assimilates produced on a sunny day are distributed and utilised well. This is achieved better at higher temperature. Therefore the temperature should be set higher when the radiation is higher.

Other reasons for temperature control are steering the plants vegetative or generative, influencing the product quality, providing adequate working conditions for staff, or affecting the humidity (see next).

Temperature and humidity are coupled

Temperature control inevitably has a link to humidity control. Without going into details, we touch on some things. Heating increases the temperature and at the same time reduces the relative humidity. However, this stimulates plant transpiration, which means that more moisture is introduced into the greenhouse air. Ventilation is then applied to remove the extra moisture. Heating and/or venting can therefore be used to control temperature and humidity, and so to influence transpiration, water & nutrient uptake, produce quality, and problems such as blossom-end-rot.

A special situation occurs early in the morning. At sun-rise, the whole greenhouse warms up quickly, but the fruits stay cold for a long time due to their mass. Water vapour from the air condensates on these cold fruit and make the fruit wet. Wet fruit become easily infected by grey mould (*Botrytis*). The remedy is to raise the set point for greenhouse temperature long before sun-rise. If heating starts early enough, the fruits can warm up too. By the time the sun comes out, the fruit are warm, and condensation on fruit does not occur. This is an example of temperature control for avoiding humidity problems. To keep things simple, only the temperature and not the humidity will be considered in the following paragraphs.

Light-dependent heating and venting

As described under 'Reasons for temperature settings', plants require higher temperature at day-time than at night, and an even higher temperature during sunshine than during dull weather. Tomatoes and capsicums may be grown at for example 18 °C at night, 21 °C on a dull day, and 25 °C on a sunny day. Obviously the free energy from the sun should be utilised. During dull weather, heating is set at 21 °C. If the temperature rises above 21 °C, the heating should switch off automatically. If the temperature rises further and reaches 21.5 °C, the venting should kick in. The difference between heating and venting (in this case 0.5 °C) is called the dead zone.

On a sunny day, the sun will increase the temperature very fast without heating. Venting should now kick in at a higher temperature, e.g. 25 °C. This is achieved automatically by setting a light-dependent temperature increase on ventilation: for instance a 4 °C increase, starting at 100 W/m² with maximum influence at 300 W/m² light level. This makes that at light level 100 W/m² the venting temperature is 21 °C; at light level 200 W/m² the venting temperature is 23 °C, and at light level 300 W/m² or more, the venting temperature is 25 °C. Although the heating temperature is less relevant during sun shine, it is often made slightly light-dependent too.

P-band adjustment

Many computers systems use a P-band (proportional band) for heating, venting and other factors. The P-band for ventilation is the temperature difference between when windows are closed and when windows are fully open. For instance, P-band 10 °C means: if vent opening kicks in at 21 °C, they will be fully open when the greenhouse temperature reaches 31 °C, and 50% open at 26 °C.

The P-band must be adjusted to outside conditions. When it is very cold outside, the P-band must be set very high (e.g. 20 °C). This means that the vents would only be completely open if the greenhouse temperature would get 20 °C too high (which is unrealistic). Thus at slightly too high greenhouse temperature, the vents are opened only on a small crack, which is sufficient to reduce the greenhouse temperature. In contrast, the P-band should be small (5 °C) in hot weather. This causes immediate wide vent opening when the greenhouse temperature becomes slightly too high. For instance at a greenhouse temperature 5 °C too high, the vents will be fully open.

Other adjustments for temperature control

As described above, lower outside temperature requires a larger P-band for venting. Similarly, higher wind speed requires a larger P-band for venting. There are many more settings such as limited vent opening at frost, rain and gales. With windows on two sides of the roof, both sides can have their own settings, but are also linked to each other. Also heating control involves P-bands and P-band adjustments, even more due to all sorts of complications. The relation between heating and venting, for instance the dead zone, is important too.

All these set-points and P-bands, for up to six periods per day, can never be adjusted all the time by the grower. Fortunately the computer control programme can do this tedious and critical work. The programme adjusts the P-band based on measured radiation, wind speed, wind direction and outside temperature. Modern computers even take the weather forecast into account. The grower has a very important role, thought, as he chooses the settings that determine the set points and adjustments.

Minimum pipe heating

Heating and venting can also operate at the same time. This is often done deliberately for humidity control. A common phenomenon is the so called minimum pipe temperature. This means that the heating pipes are kept above a certain temperature, e.g. 50 °C, even if it is sufficiently warm in the greenhouse. The minimum pipe temperature has several functions including keeping the plants dry when the humidity is high, stimulating air movement, stimulating transpiration, so-called activation of the plants, or enabling CO₂ enrichment. Warm heating pipes and the vents open at the same time can be beneficial at times, but it costs a lot of energy.

Opportunities for energy conservation

Instead of using minimum pipe temperature, and instead of heating and venting at the same time, there is a new approach now. It looks at what actions are best for the plant and for everything else. Replacing the minimum pipe temperature by smarter control strategies may save 10-20% energy without reducing the production or quality.

The examples mentioned above are just the tip of the iceberg of all the options present in advanced climate control computers. Many growers never dig into this iceberg, and just keep the settings as they were set when the computer was first installed. They miss out on opportunities for optimal plant growth and yield, and pay higher energy bills than necessary. Further articles will discuss the use of smart settings in the climate control computer to achieve energy conservation.

Acknowledgements *With thanks to Roelf Schreuder and Richard Hectors.*