Humidity control by pre-dawn heating, purging and P-band

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The energy consumption in a greenhouse depends on the weather, type of greenhouse, and also very much on the settings in the greenhouse control computer. The main factors in climate control are temperature, humidity and CO2 concentration. The growing conditions must meet the plant requirements, but there are various ways of achieving that. The previous two articles were about the basics of greenhouse air humidity. This article looks at some features offered by control computers, such as pre-dawn heating, 'purging' and P-bands for ventilation control. Different computer brands use different methods and different terms. A good understanding of what they do helps to choose the optimal settings and to prevent crop problems, wear & tear on the vents and waste of energy. Some principles of humidity control are discussed below.

Pre-dawn heating
At the end of the night, the temperature has to be lifted from the night temperature (say 18 °C) to the day temperature (say 21 °C). It is important that the day temperature is reached at about sunrise (the reasons are discussed below). To raise the temperature, the computer is set at a certain *ramping rate*, e.g. 2 degrees increase per hour (or can be 1.5 degrees per hour). To raise the temperature 3 degrees at a rate of 2 degrees per hour will take 1½ hour. In that case the ramping should start about 90 minutes before sunrise to reach the day temperature at sunrise. When the sun gains strength, it will quickly heat the greenhouse further, and in fact 'take over' from the heating system. Hence the computer will ensure that the heating system automatically goes down. On cold days obviously the pipes stay warm for a large part of the day.
The reason of pre-dawn heating is to have the plants at the right temperature at the moment of sunrise. This avoids condensation and mould problems such as grey mould (Botrytis). Without pre-dawn heating, the sun would quickly warm up the leaves, but not the solid plant parts such as fruit, buds and stems. These are full of water, therefore slow to warm up, and hence their temperature would be below the dewpoint for some hours. At sunrise the stomata (pores in the leaves) open in response to the daylight, and the plant starts transpiring. This increases the air humidity. Cold plant parts would get wet by condensation and attacked by moulds. Pre-dawn heating prevents this.

Purging
Early morning in the morning there are two effects that stimulate the plant transpiration: heating and increasing sunlight. Transpiration is desirable, as it creates a water flow through the plants from the roots to the leaves. The water flow is a vehicle for nutrient transport. But transpiration also increases the air humidity, which is not desirable for two reasons: firstly condensation on the plants (see above) and secondly too high humidity hampers the transpiration and thus nutrient uptake. Therefore any excessive moisture must be removed after pre-dawn heating and sunrise. This must be done by venting. Meanwhile the pipes have to stay warm to maintain the required temperature. A short burst of venting to remove moisture from the greenhouse air, possibly combined with heating at the same time, is called 'purging' in some computer brands.

Purging is very effective. Moist air is lighter than dry air (this may be strange, but the fact is that water molecules are lighter than air molecules). So moisture naturally rises and goes out quickly through the roof windows. This happens even when it is wet outside, as long as the outside temperature is lower than the inside temperature. However, it is also true that warm air is lighter than cold air. Hence warm air from the greenhouse also rises quickly and leaves the greenhouse. Hence venting to remove moisture comes at a cost: loss of heat.
Because we want to minimise heat loss from the greenhouse, any venting on cold or windy days should be done carefully. It depends on the choice of the setpoints whether purging is efficient and economic, or if it unnecessarily wastes energy.

Start venting
In most computer brands, the grower chooses the settings such as the start temperature and the P-band for vent control (and much more settings such as overrides). The settings should be different for different periods of the day. In winter at night the start temperature for venting is set quite high, namely several degrees above the heating temperature. This ensures that the vents won't open at night. In the early morning period, to achieve venting for humidity control, the start temperature for venting is set only just above the heating temperature. For instance the heating setpoint is 21 °C, and the start point for venting is set at 21.5 °C. A difference of only 0.5 degree between heating temperature and vent start temperature makes that the vents open promptly in response to a small rise in temperature. The vent opening allows moist air to escape from the greenhouse, as was described above under purging.
However, at the same time also some heat escapes from the greenhouse, so the temperature drops. The next minute the measured temperature in the greenhouse will be below the start temperature for venting, so the computer will close the vents. The temperature can also be below the heating temperature and in that case the computer will activate the heating system (e.g. increase the pipe temperature). Shortly after that it may become too hot, so that the vents are opened again. This way of repeated venting and heating removes the moisture all right, but the loss of heat and subsequent increase in pipe temperature costs a lot of energy. In addition, frequent opening of vents causes unrest and wear & tear.

P-band
The secret of humidity control is to do it carefully. Especially on cold and windy days, the vents should be opened only on a small crack, and only on the leeside. How fast and how wide the vents will open is determined by the P-band. In cold winter conditions the P-band should be set quite high, for instance 10 degrees. In summer it should be small, e.g. 2 degrees.
The P-band is the number of degrees between 0% opening and 100% opening. For instance, if the start temperature for venting is 22 °C, and the P-band is 10 °C, then the vents will be fully open when the greenhouse air temperature would reach 32 °C. The opening is proportional to the temperature difference (P-band stands for Proportional-band). If the greenhouse temperature is 23 °C, which is 1 degree above the start point of venting or 1/10 of the P-band, then the windows will be open 10%. If the greenhouse temperature would be 24 °C which is 2 degrees above the start vent temperature, or 20% of the P-band, the windows would be open for 20%. It is important to understand that by choosing the P-band wider, the vents open slower.
In summer the vents need to open much further and quicker. When the sun is very powerful it can quickly heat up the greenhouse. This requires a short P-band, e.g. 2 degrees. This makes that the vents are fully open if the measured greenhouse temperature is only 2 degrees beyond the start point for venting, for instance venting starts at 22 °C, is half open at 23 °C and fully open at 24 °C.

Lee and wind side

Common practice is to start venting at the lee-side. This is especially important in cold weather. Venting at the windward side can be added when necessary, especially in warmer weather. In really warm weather both side will be fully open. The computer normally has settings that allow the grower to determine when wind-side venting comes in, and how much. For instance there can be a setting saying that the wind-side vents will open when the lee-side is 50% open. Obviously the wind direction has to be measured. When the wind direction changes, the vent opening changes too, because lee-side vents suddenly become wind-side vents.

Further settings

The start point for venting and the P-band as discussed above are only the basic settings for ventilation control. Advanced greenhouse computers have many more settings, for instance 'influences', 'overrides' and 'delays'. 'Influences' apply automatic adjustments for the effect of radiation, radiation sum, and humidity. For instance the *radiation influence* causes venting to start at a higher temperature when it is sunny. In modern computers there are also influences for temperature integration.

There are often 'overrides' for strong wind, rain or frost: then the vent opening will be restricted to protect the crop. The basic setting plus influences plus overrides plus delays dictate the actual vent opening. Also there are other ways of humidity control, e.g. using minimum vent opening, or minimum pipe temperature. These and other strategies will be discussed later.

***Figure**. Reasons and methods of venting*

Here venting can be necessary either for removing moist air from the greenhouse, or for stimulating plant transpiration on a dull day.

Venting can be done either in small bursts (called 'purging' in some systems) or continuously. This venting can be dictated by a humidity measurement, or by minimum venting. It can be done on one side (usually lee-side) or like here on both sides. Heating can be needed at the same time, which obviously costs energy.