

Temperature integration

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Growers in Europe use a range of options for temperature control, including minimum pipe temperature, average temperature, dif, lower pre-night temperature, increased afternoon temperature, higher temperature after midnight, grow pipe, thermal screen, and temperature integration. These are all effective tools for manipulating plant growth and development, and for steering the plants in vegetative or generative direction. They also have an impact on the energy consumption. Temperature integration is available also in NZ, but only on advanced greenhouse control computers. It is certainly worthwhile, also for NZ conditions. However, a special feature of temperature integration that is based on weather prediction can be a bit dubious in NZ.

Temperature integration is a fairly complex feature, and requires a good understanding of all the pros and cons. First we summarise the basic effects of temperature (which were discussed in the previous article). Then we discuss temperature integration and its benefits.

Average temperature and 'dif'

Temperature affects the rate (= speed) at which plant processes occur. Most processes go faster at higher temperature, e.g. new leaves and new flowers (or trusses) appear faster at higher temperature. The down-side is that higher temperature also increases the rate of respiration (burning of assimilates). The temperature must be in balance with the light conditions. At lower light levels, the photosynthesis is lower and thus less assimilates (sugars) are produced. The combination of high temperature and low light conditions is not good: only a small amount of assimilates is formed and much assimilates are burned due to the higher temperature. This causes assimilate shortage, and hence thin plant heads and small fruit. Moreover, at high temperature the development rate is fast, which requires extra assimilates. In contrast, after a light day, there are many assimilates waiting to be processed. This requires a high temperature. Generally higher light levels require (or tolerate) higher temperature. Fortunately this works well: higher light level means there is sunshine, and that means free energy to elevate the temperature.

'Dif'

Most processes go faster at higher temperature, but fruit set is an exception. Tomatoes and capsicums require a cool period at night to allow fruit set. Therefore growers use 'dif', which means 'difference between day and night temperature'. A larger dif means cooler night temperature. This results in more fruit set, and hence a more generative plant. Lower dif means that the day and night temperature are more equal, or in other words that the night temperature is fairly high. This results in less fruit set and more weight gain in the top of the plant, i.e. a more vegetative plant.

Pre-night temperature

Warm plant parts attract more assimilates than cold plant parts. This principle is the basis of the pre-night temperature drop. In the early evening, two things happen: (1) the leaves are full of sugars and (2) the outside temperature is going down. The trick is to quickly drop the temperature in the greenhouse by a few degrees (by venting). The leaves will quickly adopt the lower temperature. However, but the more solid plant parts such as fruit will stay warmer than the leaves. Because the fruit are warmer, they will attract the sugars. This must be accompanied by a somewhat higher temperature after midnight in order to achieve the required 24 hour average temperature. In addition a higher temperature in the late afternoon can strengthen the effect of lower pre-night temperature.

Temperature integration

Temperature integration is about flexibility in temperature control. The conventional way is maintaining a flat line for day temperature and a somewhat lower flat line for night temperature, with ramping in between. Temperature integration means that certain temperature fluctuations are accepted, as long as a certain required average temperature is achieved over a period of several days. The computer calculates the degree-hours and degree-days and the deviations, and makes sure that the crop receives the required amount of warmth. If the temperature is one degree above the required average temperature for one hour, this is calculated as one degree-hour (deviation). If the temperature is then 2 degrees below the setpoint for 3 hours, this is minus 6 degree-hours (negative 6 degree-hours deviation in temperature sum). The net total is then negative 5 degree-hours. This can be compensated by giving 5 hours at 1 degree too warm. The computer control programme ensures that the deviation is never beyond certain limits. The grower can choose the deviation, or the upper and lower limit, and also the integration period. The programme allows a 'dif' to be maintained in combination with temperature integration, so that the grower can influence fruit set, and vegetative or generative steering.

Energy saving

Temperature integration helps achieving optimal growth and development combined with considerable energy saving. For instance when it is very cold or windy, the greenhouse temperature is allowed to drop a bit. On another moment when there is sunshine, or when a thermal screen can be closed (as they do in Europe), the temperature is allowed to be extra high. The possibilities are greater when a larger band of temperature variation is allowed, and a larger integration period. The presence of a thermal screen further increases the possibilities of temperature integration.

Weather forecast

One step further (and for most NZ growers a step too far) is including the weather forecast in the temperature integration. If the forecast for the day looks good, the computer aims for a higher average temperature from then onwards, whereas under poor weather conditions the average temperature will be maintained lower. Overseas the growers also use multi-day weather forecast. If the weather will be cold in the next days, the computer assumes that a lower temperature will be allowed in the next days. This means that a higher temperature is maintained while the weather is still good. The use of the weather forecast in combination with temperature integration is perhaps less feasible for NZ, due to considerable local fluctuations in weather and fairly great uncertainties in the weather forecast.

Feasibility

Temperature integration can save energy, also in NZ, especially in spring and autumn. When the sun is out, it will help to get some positive degree-hours during daytime at zero costs. This allows the temperature to be lower at night, when it is colder, thus saving on heating costs. Temperature integration can save energy in the winter in greenhouses with a thermal screen. The temperature is allowed to be high when the thermal screen is closed (at night) and lower when the screen is open (during the day). The benefits of using a thermal screen and temperature integration in winter can be substantial. In summer, the benefits of temperature integration are small.

In NZ, it happens quite often in cold spells that the greenhouse temperature drops below the required heating setpoint. This can be due to insufficient heating capacity, or inaccurate control or slow response for instance of a coal-fired boiler. The grower accepts this, and hopes that the temperature will soon come right. Meanwhile the crop gets a setback. It would be much better for the crop if the shortfall in warmth is compensated later. To do this accurately requires a temperature integration programme.