THE TEMPERATURE – LIGHT BALANCE

Words by Elly Nederhoff : Crophouse Ltd

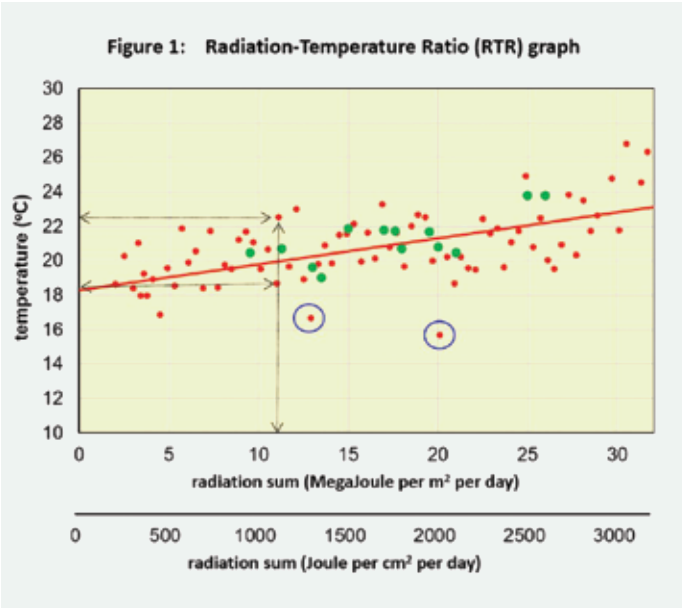

Figure 1: *The Radiation-Temperature-Ratio for a fictive greenhouse. Each dot is one day, with the radiation sum on the horizontal axis, and average 24-hour temperature on the vertical axis. Green dots are days after the computer settings were improved. Radiation is given in two units that are commonly used. The grey arrow shows a 4-degree difference between days that had the same radiation sum. The two blue circles mark incorrect measurements. Source: Crophouse Ltd.*

The key to a productive cultivation is a good balance between the average temperature in a greenhouse and the average light level.

Light determines how much sugars are produced by the plant (the source), while the temperature determines how much sugars are burnt and how the remaining sugars are distributed to the growing parts of the plant (the sinks). As discussed in last month's article, light and temperature affect many processes, including plant development, plant shape, vegetative/generative balance, and overall yield.

In this article we look in detail at the 'Radiation–Temperature Ratio' (RTR). Letsgrow in the Netherlands developed an online RTR tool that is used in 'the new way of growing' (HNT) and in Plant Empowerment. (See previous article in this series.) This RTR is applied a lot for tomatoes and capsicum, and it is relevant for many other crops too.

Average temperature

On a dull winter's day, plants prefer a low average temperature of say 18°C for tomatoes, while in summer they thrive on 24°C or more. We want to quantify the light–temperature relation. The climate control computer accurately calculates the average temperature over 24 hours. For instance on a winter's day we can have 10 hours a day at 19.5°C, and 4 hours in the evening at 16°C, plus 7 hours during the night at 17.5°C, as well as some hours ramping, resulting in 18.2°C on average. This is achieved by a higher base temperature and/or an automatic increase in the ventilation temperature with increasing light levels. Also the night temperature can be increased a bit more after a bright day than after a dull day (see previous article).

Light and radiation

Light and radiation are different things, although many people refer to 'light' when they are actually talking about radiation. The sun emanates solar radiation (aka global radiation). It is made up of nearly 50% light, 50% heat and a small fraction of ultraviolet (UV). Worldwide, it is common practice to measure solar radiation using a pyranometer, which measures light + heat + UV combined, in Watts per m2. We know the light level is around 50% of the measured radiation. It is not surprising that the words radiation and light are often mixed up.

For reliable measurements, a pyranometer is positioned outside, unshaded and clean in order to operate accurately. How much radiation (and light) reaches the plants depends on the greenhouse roof and varies between greenhouses. Note that some computer brands are fitted with a cheaper meter, such as a lux meter that measures light in totally different units.

Radiation units

Solar radiation is measured in Watts per m² (W/m²), which is exactly the same as Joule per second per m² (J/s/m²). The radiation sum is an accumulation of solar radiation multiplied by duration (in seconds), expressed in Joule per m² (J/m²). The sum over a whole day gives a large number, so for convenience we add 'Mega' and drop 6 zeros, so we get MegaJoule per m² per day. A sunny summer day can exceed 30 MJ/m²/day. Alternatively, the radiation sum is expressed per cm², and a really sunny day would give 3000 J/cm²/day, which is exactly the same as 30 MJ/m²/day. **Figure 1** shows both units along the horizontal axis.

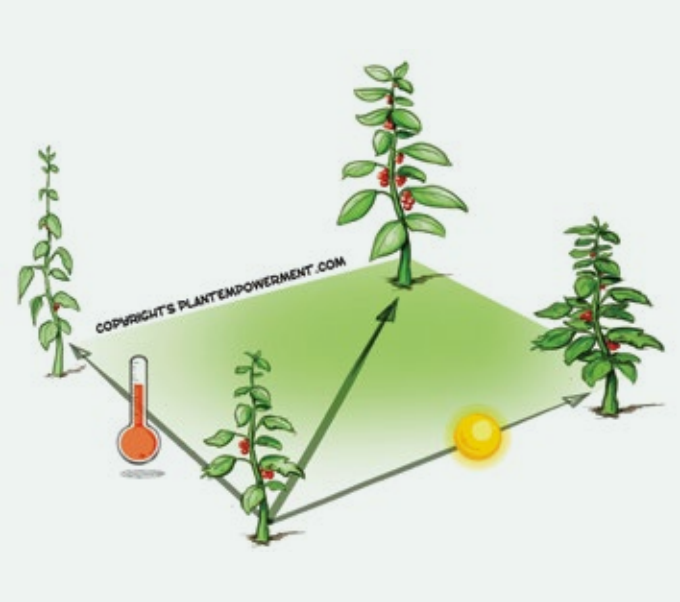

Figure 2: *The right combination of light sum and average temperature gives a balanced plant. Too warm but not enough light means plants become long and skinny. A lot of light but not enough warmth creates short stocky plants. Picture with permission from www.plantempowerment.com*

Radiation–Temperature Ratio (RTR) graph

With the computerised measurements available, we can plot the average temperature versus the radiation sum. This is called a Radiation–Temperature Ratio graph or RTR graph. Figure 1 is an example, with the radiation sum on the horizontal axis, and the average 24-hour temperature on the vertical axis. Each dot represents one day. Ideally the dots would all be on the red line, as that is the perfect RTR balance. But instead the red dots are dancing around the red line. The grey arrows point to two days that had the same radiation sum (about 11.5 MJ/m²/day), but a different average temperature (18.5 and 22.6 °C). This large difference demonstrates that radiation and temperature were not very balanced in this situation, due to an inconsistent control strategy. The two blue circles on the graph mark two dots that are obvious errors, perhaps due to a computer glitch or faulty sensor. They should have been removed.

Setpoints

Because temperature is so important, we want to find the cause of this undesirable spread of dots. First check if the data were correct or if some were accidentally wrong. Secondly, is it either the day or the night temperature that seems out of alignment? Thirdly, is the deviation most likely to do with heating or with cooling (venting, screening, fogging, use of fans, etc)? Can the deviation be due to humidity control or a faulty humidity measurement? In the Netherlands, growers perform this analysis as a group to learn 'the new way of growing' (HNT).

New data

After the computer settings have been improved, the data recording continues, and new dots are added to the RTR graph. It is a good idea to make the new dots another colour (e.g. green in Figure 1). It is great to see that the green dots sit closer to the RTR line, indicating a better radiation–temperature balance. So the changes in the settings were indeed an improvement.

RTR line

The red line on the graph is drawn through the points. It has a certain slope and a certain formula: the average temperature equals 18.3 degrees + 1.5 degree for every 1000 J/cm²/day. So at a radiation sum of 3000 J/cm2/day, the line goes through 22.8 °C (18.3 + (1.5 x 3)).

This formula tells something about the temperature strategy that was followed in a particular greenhouse. The line depends on the light transmission of the greenhouse roof, and also on how the grower decided to grow the plants. So this RTR formula is not a general recipe, but rather a method to analyse what is happening. Letsgrow made an online RTR graph to compare and analyse data.

Slope of the RTR line

The line shown in Figure 1 is not necessarily the optimal balance, not even for this greenhouse. The grower may decide to aim for a different RTR next year. Generally, a steeper line indicates a warmer environment, leading to longer (perhaps lankier) and more generative plants. A flatter line (less steep) indicates a lower average temperature, leading to lusher more vegetative plants, as shown in **Figure 2.** The art of growing is to strike and keep the right plant balance. The right Radiation–Temperature Ratio helps with that.