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Space scientists bring light research down to earth

Edward Muckle

Ah, 'tis finally the season of the sun. At least it should be for most growers in North America. The season when matching irrigation levels to incident light becomes critical to good production. In this age of computer control systems you would think that matching these levels would be easy. Unfortunately, most light sensors make it difficult. To understand the real problem you have to 'see' light as plants do.

Plants use all colors of light with similar efficiency. Blue, yellow, orange, red and even green light all provide similar energy for photosynthesis. However, humans see green light (550 nm wavelength) about 10 times more efficiently than blue or red light (400 and 700 nm wavelengths). The light meters in common use all measure light for humans, and these meters are heavily weighted to measure green light. These meters measure radiation in footcandles, and can have a 45-percent error when used to measure the photosynthetic energy in radiation.

Here on earth with 'free' light available from the sun and a very forgiving plant population, it is possible to use a footcandle meter to get a rough estimate of radiation for photosynthesis.

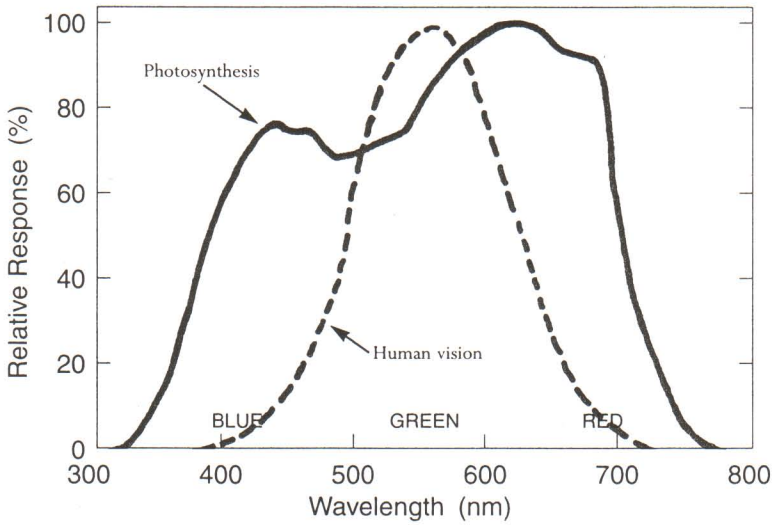
Possible—but far from optimal, as researchers for NASA's Advanced Life Support (ALS) program determined many years ago.

When researchers grow plants in space they have to provide every input for plant growth. Trying to do this in response to inaccurate information is a sure formula for failure. The only way to register light values in the same way plants do is to use a sensor which views light as photons.

Every portion of the light spectrum is identifiable by its 'color.' For plants, these colors are different energies of photons. Look at a chart

for PAR (Photosynthetically Active Radiation) and you can see which energies are of value to plants and which are reflected. Any sensor biased toward green will get a double response: once from the direct light, and a second time from the light reflected from plants.

This error is compounded when green light is only a small component of incident light because the footcandle meter has a negligible response. This phenomenon occurs during a significant portion of the photoperiod. Growers who have not been aware of this fact have lost up to 30 percent of potential production due to environment mismanagement. The majority of PAR received by plants during the photoperiod is reflected skylight. The color mix of this light differs from direct sunlight.



Research done by Ted Short at Ohio Agriculture and Research Development Center (OARDC) shows conclusively that incident PAR at one hour before sunrise and one hour after sunset on a clear day is equal to incident PAR at high noon. Verifying the error of a footcandle meter is as simple as taking a reading an hour before sunrise and another at noon. This clearly shows we need a better sensor providing input for our computer control systems.

PPF (Photosynthetic Photon Flux) meters were first developed in 1972. Since then they have been a standard for research. Unfortunately, the cost has kept them from common use in the greenhouse industry. PPF sensors and meters have cost at least four times as much as a good footcandle meter. So, many growers settled for the less expensive option without realizing the restrictions they were placing on good environment control.

Often technology from NASA research benefits the private sector. A recent development of interest to growers is the creation of a new PPF light meter for commercial applications. The sensor chip used in this light meter is the same one used in NASA research and is key to the technology. It responds to the rate of photon flow striking the sensor and it can be tuned to respond to specific wavelengths.

Dr. Bruce Bugbee, professor of crop physiology at Utah State University, has been heavily involved in the NASA-ALS research for many years. He discovered that the PPF chip sensor could be 'married' to a voltmeter producing an accurate, low-cost, hand-held PPF meter and a PPF sensor for commercial greenhouse computer control systems. Pricing is comparable to the footcandle meters.

As with any meter, having a good sensor is only half the battle; keeping it clean and calibrated is essential.

Dr. Bugbee's research may hold another benefit for growers in the near future. He is working on an infrared sensor which would allow growers to manage the greenhouse environment based on head (meristem) temperature instead of air temperature. Who knows? Some day we may actually be able to manage the greenhouse environment from the plant's eye view.