Light Matters

Designing illumination systems with high-brightness LEDs

The interplay of light and physiology is fascinating. Life has evolved to respond to light in remarkable ways. This holds true not just for the animal kingdom, but also for plants and fungi.

I recently presented a paper on the potential use of LEDs to "tailor" plant photomorphogenesis (light-mediated development) and photoperiodicity. In the hope that you may find this topic as interesting as I do, I'll summarize a few portions of it.

By using LEDs of specific wavelengths, we may be able to enhance commercial production of certain plants by improving their yield, changing their shape, increasing their health value to consumers, and directing them to flower or hold-off flowering, as needed – perhaps to coincide with "ideal" market conditions. Instead of "grow lights" which augment photosynthesis, the technology might be thought of as "control lights".

Many plant species appear to judge the gradual varying length of darkness each night as a seasonal cue. When a certain time threshold of darkness is reached, actions are triggered. It could be a signal to germinate early so the plant gains a competitive advantage or avoids leaf canopies; it could be a signal to delay flowering or fruit development because of an impending annual drought which the plant has conditioned itself to over millennia.

Based on their photoperiodic response, we can place plants in three broad categories:

Short-day plants (SDP): Flower or flower more rapidly when the number of hours of darkness exceed a certain threshold

Long-day plants (LDP): Flower or flower more rapidly when the number of hours of darkness is less than a certain threshold

Daylength-neutral plants (DNP): Flower at the same time irrespective of the light/dark period

Short-Day Plants	Long-Day Plants	Day-Neutral Plan
Rice	Spinach	Tomato
Soybean	Radish	Cucumber
Morning Glory	Arabidopsis	Rose

Figure 1 – Photoperiodicity of a few representative plants (note that for some species such as Morning Glory, temperature also has an effect)

When a short day plant (SDP) is in the dark for more than the required time, it enters the flowering stage. If the dark period is shorter, it spends its energy in other ways, such as root development. For long-day plants (LDP), it's the opposite.

A remarkable thing happens if you interrupt the darkness, even very briefly. Experiments indicate that several minutes of far-red light from an LED array during the dark will keep a short-day plant in the vegetative state and initiate flowering in a long-day plant. Note that many plants have yet to be characterized with regard to their photoperiodicity— there is still much to learn. Evidence suggests the underlying mechanism involves a plant pigment called phytochrome. Phytochrome exists in two interchangeable forms. Red light converts the biologically inactive phytochrome Pr into its bio-active form Pfr. In the dark of night, Pfr slowly converts back to Pr. A short burst of far-red light in the night (not an event a plant would encounter in nature) converts Pfr back into Pr immediately, like pressing a photoperiodicity reset button.

Spectral content of light is also "analyzed" by some plants as a signal that other plants are nearby— thus they should invest more energy in growing taller, to favorably compete for sunlight. Natural sunlight that reaches a plant contains more red than far-red. In that case, the plant grows normally. Tree bark, however, absorbs more red and reflects far-red. Tall neighboring leaves above the plant absorb more red and pass more far-red. As a result, a plant in the area near or under other plants tends to have more far-red than red. The plant responds to this condition by growing taller or longer, a behavior known as shade avoidance syndrome.

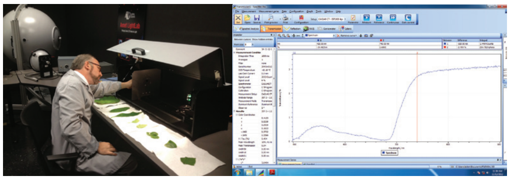

Figure 2 – Using a spectrophotometer and modified goniometer in the Avnet LightLab, I measured the spectral characteristics of various leaf samples.

To determine if the light from a set of fixed wavelength red and far-red LEDs could be used to induce shade avoidance syndrome with a variety of plants, I measured a wide sample of leaves in our LightLab. Every leaf exhibited a remarkably similar pass and stop at the same red and far-red wavelengths, as seen on the right above.

LEDs are certain to play an increasingly important role in horticulture and floriculture. Your questions and comments are always welcome. This and other Light Matters articles are downloadable at www.em.avnet.com/LightSpeed

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is Global Director of the Solid State Lighting and Advanced LED business unit of Avnet Electronics Marketing. An ardent advocate of energy efficient LED-based illumination, he has worked closely with LED manufacturers, advanced analog IC and secondary optics vendors since his first patent using LEDs was issued two decades ago. Avnet works with customers through their national team of illumination-focused sales engineers who are experienced in thermal, drive stage and optics design. Prior to his LED lighting focus, Cary was Avnet's technical director and managed Avnet's North American FAE team.

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