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ELECTRONICS

LEDs Lead the Way for Horticultural Lighting

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Horticultural lighting is one of the fastest growing markets in the LED lighting industry today. Currently estimated at being worth \$690 million dollars annually by LEDInside, this figure is projected to reach billions in the coming years.

The dynamics behind this growth are based on horticultural lighting's ability to improve crop yields. Artificial illumination of indoor environments allows for extended growing seasons, or even year-round crop production. When using LEDs, the wavelengths of horticultural lighting can be fine-tuned to ones that are optimal for improved plant growth, or to encourage the highest nutritional value. All this translates directly into higher revenues for farmers - making solid state horticultural lighting an obvious choice for cutting-edge agricultural applications and offering a means via which to address ongoing concerns about future food shortages.

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The Need for Horticultural Lighting

For thousands of years, humankind has depended on the sun to provide the light needed for farming, but natural sunlight has a number of disadvantages.

1. It is seasonal - with short days in the winter and long ones in the summer.
2. Furthermore, keeping crops outside exposes them to the whims of the weather - frost and cold in the winter, blazing heat in the summer, and storms or irregular weather patterns that can ruin a growing season overnight.

The unpredictability of traditional, outdoor agriculture has led to the increasing use of indoor growing techniques. Greenhouses allow farmers to control conditions (including temperature and humidity) while still taking advantage of natural lighting. The recent development of vertical farming sacrifices natural lighting for high density crop production in urban environments, as well as the ability to precisely control all aspects which affect plant growing conditions.



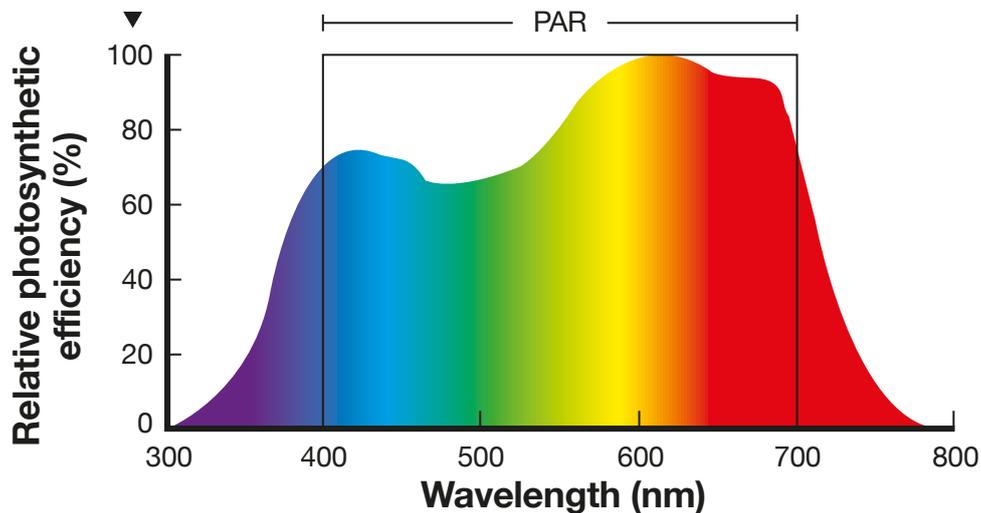


Horticultural lighting can be applied to both these types of indoor growing techniques. For greenhouses, it can supplement natural lighting. Farmers can thus kick-start a growing season early, allowing more harvests per year. For vertical farming - artificial lighting is the only option. By fully controlling the lighting, growers have complete control over the growing season, as well as the ability to fine-tune or even accelerate various stages of plant growth.

Changes to the Fundamental Technology

High pressure sodium (HPS) lighting has traditionally been the light source of choice for grow lights because of its relatively high efficiency and wavelength. HPS light has a spectrum with plenty of yellow, red and far-red, which encourages flowering. With lighting efficiency of over 100lumens/Watt, HPS lights have outperformed incandescent, fluorescent, or older LED lighting solutions. In recent years, however, the industry has switching over to solid state alternatives. This is due to the superior energy efficiency, plus the better control over lighting quality and distribution that are associated with LED devices.

It is important to recognise that horticultural lighting needs are quite different from normal lighting requirements. While normal everyday lighting is optimised for the human eye, horticultural lighting needs to be suitable for maximising plant growth. Light in the wavelengths relevant for horticulture is called photosynthetically active radiation (PAR) and lies in the 400nm to 700nm range. PAR is measured in Watts/m², rather than lumens/Watt.



Since any light outside of the PAR band is effectively wasted in terms of its horticultural value, the ability of LEDs to output PAR wavelengths means they are significantly more energy efficient than HPS lighting sources at facilitating plant growth. LED-based substitutes for HPS lighting, such as Plessey's high power grow lights, offer 40% energy savings compared to traditional grow lighting.



Figure 1: Plessey's Hyperion horticultural lighting modules (Source: Plessey).

LED lighting also provides far greater control over lighting quality, spectral output, directionality and spread than HPS lighting sources. Whereas HPS bulbs output light in all directions, LED light sources can be much more targeted. Lighting is generally output at 180 degrees, and the beam can subsequently be focused or spread to the desired angle and distribution using appropriate LED optics. By controlling beam spread, lighting can be concentrated on just the plant/s - thereby reducing wasted light. In addition, careful choice of LED lighting and optics can allow growers to adjust the spectral output of the LED lighting over time. Since different stages of plant growth are boosted by certain wavelengths, spectral output can be chosen to accentuate growth during each stage.

LEDs also allow for precise dimming, thus delivering fine control of light output. Luminosity can be tailored to the exact amount needed for a specific point in a plant's growth. Besides energy savings, this means that a reduction in excess heat is realised - reducing water consumption, as well as maintaining longer service life. High quality HPS lighting will last 24,000 hours, but LEDs will operate for even longer - with service lives of 35,000 hours to 100,000 hours being typical. Critically, the light coming from HPS sources will shift in spectrum over time towards the green/yellow range - which is poorly utilized by plants. This means they may need to be replaced even before end-of-life just to maintain proper lighting quality. LED lighting, on the other hand, stays much more spectrally consistent over time. Combined with the ability of LEDs to be easily built into robust, IP67 waterproof and dustproof fixtures, LEDs provide low maintenance horticultural lighting solutions with prolonged operation.

Lighting for Greenhouses

Greenhouses allow farmers to control environmental conditions while still taking advantage of freely available natural sunlight. Pests or severe weather don't need to be worried about, and the humidity and temperature can be carefully controlled. Through the addition of horticultural lighting, the growing season can be extended all year round. In addition, LED light targeting specific wavelengths can be used to supplement natural sunlight and encourage certain parts of the plant's growth cycle (boosting stem growth for instance, or causing roses to grow more compactly for aesthetic purposes).

Greenhouse lighting typically consists of high bay LED fixtures in either full-spectrum daylight substitution (enabling more grow cycles within a year), or targeted wavelengths (to improve crop yields and quality). In one trial in the Netherlands, where PAR-focussed Plessey Hyperion modules were specified, 35% better yields were witnessed than had been possible with traditional HPS-based horticultural lighting.



Figure 2: The LUXEON SunPlus horticultural lighting solutions from Lumileds (Source: Lumileds).

Lighting for Vertical Farming

With vertical farming techniques, high density crop production can happen in locations that are closer to (or even within) cities, reducing transportation costs and enhancing produce freshness. Here layers of plants are stacked on top of each other, so as to maximise space usage. With vertical farming, sunlight is not an option, and artificial lighting therefore has to provide 100% of the illumination. Lighting fixtures for vertical farming are typically smaller, allowing for even finer grained control over the light that individual plants receive. Because this type of light is a substitute, not a supplement for sunlight, lighting intensity needs to be considerably higher than that for greenhouse lighting. Energy efficiency is critical and so is thermal performance - as lighting is driven brighter, more heat is produced, which can negatively affect plant growth.



For vertical farming targeted wavelengths are even more effective than in greenhouse lighting, as there is complete control over the lighting conditions. Horticultural LEDs such as the Lumileds LUXEON SunPlus series come in targeted spectrums that can maximise photosynthesis or address photoperiodism (the response plants have to seasonal changes in light). A study¹ done conducted with these LEDs found conclusively that targeted wavelengths can lead to increased crop yields, while simultaneously improving the nutritional profile. Compared to RGB lighting, the SunPlus Lime+Purple LEDs and Green+Purple LEDs were able to improve yields and also raise the concentrations of anthocyanins and carotenoids.

¹https://eu.mouser.com/pdfdocs/Lumileds_LUXEON_SunPlus_Whitepaper.pdf

Illuminating the Future of Food

Horticultural lighting is helping to modernise agriculture/horticulture. It is allowing for better crop yields, improved produce quality and continuous crop production. It is also a key enabler for new farming practices. While HPS lighting was the dominant technology in the past, times have changed and now LEDs are leading the way forward with heightened energy efficiency, better thermal performance, and the ability to provide targeted spectral output to precisely control and encourage plant growth.



More information on Mouser Electronics' LED products can be found here:
www.mouser.com/Optoelectronics/LED-Lighting/_/N-74g9t/



Additional Reading

Vertical Farming:

www.mouser.com/pdfdocs/EIT-Vertical-Farming.pdf

Horticulture Lighting Applications:

www.mouser.com/applications/lighting_application_horticulture/

LUXEON SunPlus Series Lime LEDs Produce High Yield and Nutrition in Leafy Greens:

www.mouser.com/pdfdocs/Lumileds_LUXEON_SunPlus_Whitepaper.pdf



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