Horticultural LED advances offer unprecedented power to growers

BY PENNY JONES

As opportunities mount and the economic potential begins to sink in, there is little doubt that horticultural lighting has got the lighting industry in a quiver. The vision: a future where year-round sustainable fruit, vegetable and flower cultivation flourishes indoors under the tailored gleam of LEDs.

Horticulture is a type of agriculture that focuses on specialty (high value) crops in which production is quite intensive. The aim of horticulture is to improve plant qualities such as growth, production cycle, yield, quality and nutritional value.

Indoor horticulture started with the construction of the first modern greenhouse in the late 1800s, and it wasn't long before electric 'grow lights', designed to stimulate plant growth and photosynthesis, were trialled and adopted as common practice. This tootled along quite happily, with gradual technological advances, until about five years ago, when, like so many other industries, LEDs came along to detonate the traditional ways of doing things.

In terms of the scale of the opportunity, market research, published by MarketsandMarkets in 2018, reported that the horticulture lighting market is expected to grow from USD 2.43 billion in 2018 to USD 6.21 billion in 2023. Furthermore, a 2018 report by OpenPR expects the Asia Pacific region to be the fastest-growing market due to rapid population growth, urbanisation and the limited availability of agricultural land.

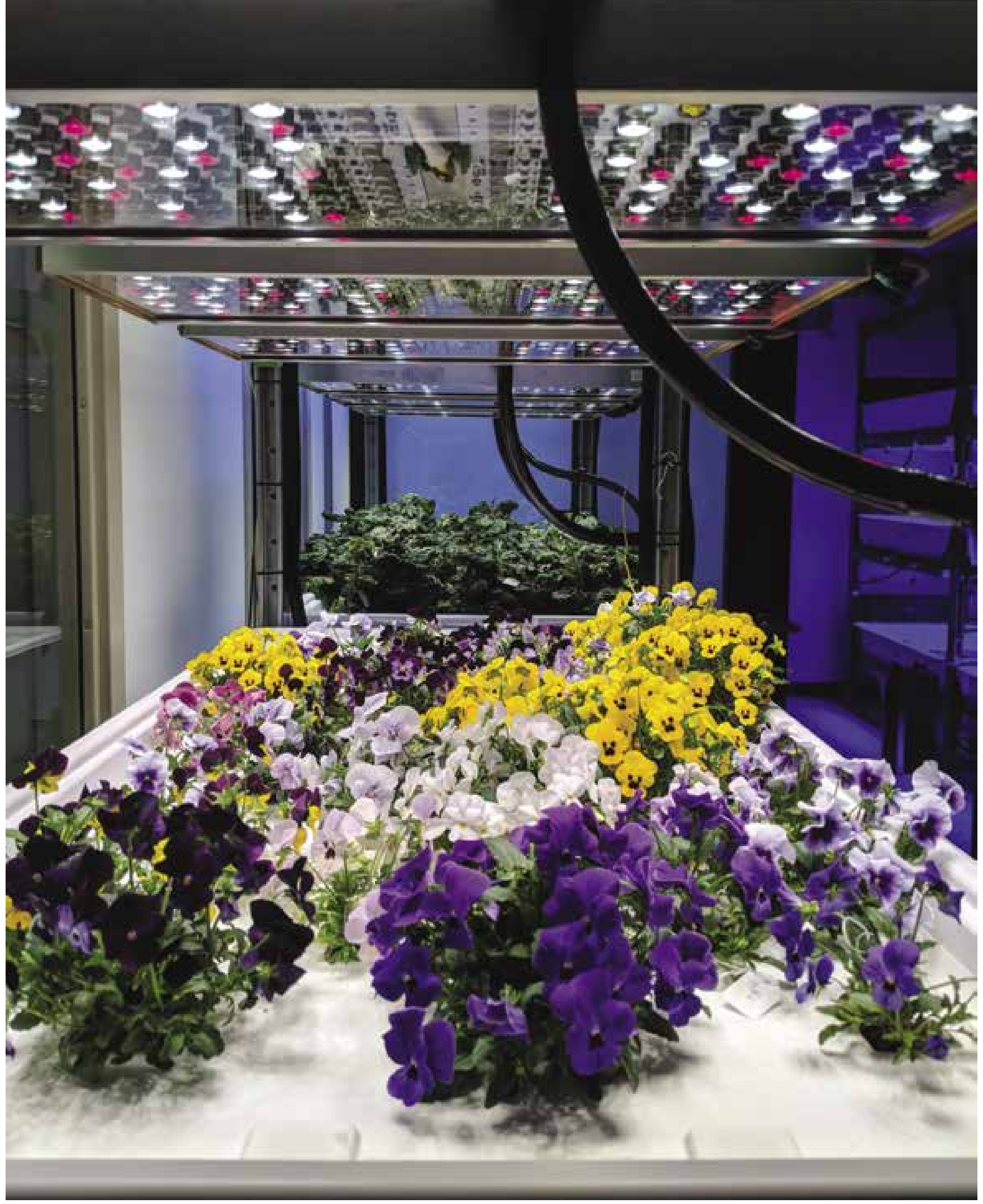
Horticultural lighting can give unprecedented power to growers by allowing them to control the length of exposure (i.e. the length of time light is sent to the plant), and the light intensity (i.e. how much light is sent to the plant). Unique to LEDs, however, is a new power: the ability to tailor the quality of the light, or in other words regulate the light spectrum in order to elicit the specific/desired attributes you want from the individual plant.

Credit Erik Runkle.

Research on indoor LED lighting of leafy greens performed in the Controlled-Environment Lighting Laboratory at Michigan State University.

By working with these three light parameters, you can create a 'light recipe' for optimal growing and environments where certain plants can be cultivated in indoor farms or greenhouses, year-round, with reduced energy and water requirements, faster growth, increased yield, and potentially better taste, colour and nutritional content.

There is also strong evidence that pesticide use can be greatly reduced, or even no longer required, and, because you are tailoring the environment to the plant, as opposed to the other way around, there will be less need to genetically modify seeds, and more opportunities to return to rare and heirloom seed varieties.



Pansy and cherry tomato grown as edibles inside the Controlled-Environment Lighting Laboratory at Michigan State University.

As you would expect, academic research in the field is flourishing and lighting companies are investing heavily in R&D. However, as a multidisciplinary field (lighting is just one important factor, there are also things like soil, temperature, fertiliser and irrigation to consider), lighting companies wanting to get in on the act must tread carefully. There is so much more to growing indoors than just illumination.

Dr Abhay Thosar is a Senior Plant Specialist at Signify in Chicago in the United States and says their customer model involves close collaboration between the plant specialist, the lighting engineer, the sales manager and the grower. He says the complex nature of the lighting requirement, and all the influencing factors, means they must work to create a complete solution.

"The first thing to understand is that lighting for plants is very different to lighting for humans. For humans, we measure light in lux or lumens, but for plants, for which light is food, we measure light in micromoles, or the number of light photons that can be absorbed by the plant. Ten micromoles might provide enough light for a person to read a newspaper at night, for example, but it is nowhere near enough for a plant to maximise photosynthesis," he says.

Thosar explains that moles of photons measure the accumulated light in plants per day and says we can compare this to the daily calorie intake a person needs. Just as calorie intake varies for humans based on their height, weight and physical activity, the same is true for plants.

"It is important to calculate the optimal light intensity to deliver the plant's requirement of moles per day in any lighting solution we devise," he continues.

Another key difference between human and plant lighting is that humans are most sensitive to the yellow, orange and green wavelengths on the light spectrum, whereas plants are most sensitive to green, far red and blue. These are the colours that excite the electrons, promote photosynthetic and chlorophyll activity, and it is in this area that LEDs are having the biggest impact on the industry.

Says Thosar: “The ability to control the light intensity and spectrum with LEDs changes everything. Manipulating these elements directly impacts the plant’s physiological processes and photomorphogenic response and can result in big changes in how the crop responds. As a plant physiologist, these advances are incredibly exciting and put me in full gear to try out many different options.”

Erik Runkle is a Professor in the Department of Horticulture at Michigan State University and works closely with greenhouse and indoor plant growers and performs applied research in horticultural lighting. He developed the Controlled-Environment Lighting Lab (CELL), which was launched in mid-2017 in partnership with multinational LED producer Osram. CELL’s mission is to better understand how the light spectrum can be manipulated in order to produce crops with desired qualities.

“Using LEDs, you can deliver specific colour wavelengths to plants at different stages of growth. At CELL, we perform experiments on a range of herbaceous specialty crops in controlled environments to determine the effects of light intensity and spectrum on growth and flowering,” explains Runkle.

“We want to understand how individual colours, or different wavebands of light, influence plant development, and also how they interact with each other, in order to increase productivity and encourage development of other desired attributes.”

Runkle is keen to point out that they are not trying to solve the global food problem using indoor growing, (which is considerably more expensive than field or greenhouse production), but readily acknowledges the huge opportunities specialised LEDs can have on the cultivation of certain crops.

“There are a growing number of people who are proponents of vertical farming and indoor growing and we believe we will soon

Bowery Farming, a producer of herbs and salads etc. located near New York city, uses RAZR 4 and SPYDRx LED light solutions from Fluence Bioengineering to create ideal conditions in its vertical farms.

Credit Fluence Bioengineering, Inc.

Credit Fluence Bioengineering, Inc.

Hällnäs Handelsträdgård, a producer of herbs and ornamental flowers located south of the Arctic Circle in Northern Sweden, uses LED lighting for growing plants inhouse.

create vastly improved and economically viable conditions to grow certain high-value crops that meet specific characteristics. What we won’t be able to do, in the short term at least, is solve the world’s food problems by growing plants indoors. Any talk about how indoor growing will feed the next billion people in the world is absurd,” he says.

“When we talk about vertical farming and indoor plant production, we’re not talking about agronomic crops i.e. corn, wheat or soybeans. Rather, we’re talking about horticultural crops with specific quality or growth attributes. This might be a crop that has a short production time, has a high value, is perishable, occupies a small amount of space and/or has a high harvestable index.”

Runkle says CELL is currently focusing on two key crop segments: leafy greens (i.e. lettuce, basil and kale) and floriculture crops (i.e. garden plants such as annual bedding plants). “Leafy greens because they have a short production cycle, you can harvest pretty much the whole plant and they take up a small growing space. Floriculture crops because they have a very high value, and there could be a price premium for greater uniformity,” he continues.

The research coming out of CELL, and from others working in the field, is so promising that Runkle is confident that the range of specialised LEDs for vertical farming and existing greenhouses will expand quickly.

“We are already starting to see companies producing specialised LED fixtures that can be programmed to create exactly the sort of traits you’re looking for in your crop. Vertical farming is still in its infancy but will prove a more sustainable and economically attractive solution to growing crops such as lettuce in the near future,” he says.

“Take a very dry area like Los Angeles, for example. With indoor farming you could grow high quality lettuce indoors, using just 10-20% of the amount of water as a field, and have a short shipping distance.”

Thosar agrees. “Right now people are getting their feet wet in the possibilities, but I think a time will come when a customer can say, ‘I want to grow tomatoes with X percentage of vitamin C’ or ‘I want to grow lettuce with red leaves,’ and companies will be able to provide a recipe of elements to produce that specific plant.”

The products and technologies impacting LED horticultural applications are focused on both light intensity and the ‘spectrum dialling’ ability for both vertical farms and supplementary lighting for greenhouses.

Supplementary lighting is used in two ways. First, to improve plant photosynthesis and therefore productivity. The second is photoperiodic, which means optimising and controlling the lighting period beyond daylight hours to 'trick' the plant into behaving in a certain way i.e. flowering. In some areas of the world at certain times of year there is a definite need for supplementary lighting in order to meet the daily quota of moles of photons for optimised plants. Tomatoes and cucumbers, for example, are plants that growers tend to light up during the winter months to increase productivity.

Timo Bongartz is the Head of Smart Farming at Osram in Munich, Germany and says Osram's approach has been to integrate its expertise in lighting technologies with horticultural knowledge from its partners, to develop lighting solutions to improve the yields and quality of plants.

Credit Erik Runkle.

Lettuce grown under different light quality treatments in the Controlled-Environment Lighting Laboratory at Michigan State University.

"We are investigating many different crops and growing methods to work out the best application fit of our LED technologies. Because LEDs are small, cool and flexible, you can get them very close to the plant which is interesting for growing herbs vertically (buzzword: vertical farming), and we are developing lighting for high-wire crops like tomatoes, cucumbers and peppers that can go on top and in between plants," he says.

Although much of the horticultural lighting sector still uses fluorescent tubes, high pressure sodium or metal halide lamps, particularly for pure artificial lighting, Bongartz says change is definitely underway.

"The majority of new vertical farms will only use LED now, and in medicinal crops, like cannabis, growers are switching across to LED. I think the tipping point for supplementary lighting, especially for tomatoes, will probably happen this year."

Bongartz says that when it comes to lighting it is always a combination of finding the right form factor and the right spectrum, but to get the best results, it is also important to understand the other environmental conditions in a greenhouse or vertical farm.

"As part of our Smart Farming offering, we are testing a range of different sensors to better understand the microclimate in the grow space, and an IoT platform to control and steer the light. The benefit for the grower is accurate, granular data and a user-friendly interface they can use as a tool to tweak different aspects to optimise their growing operation," he says.

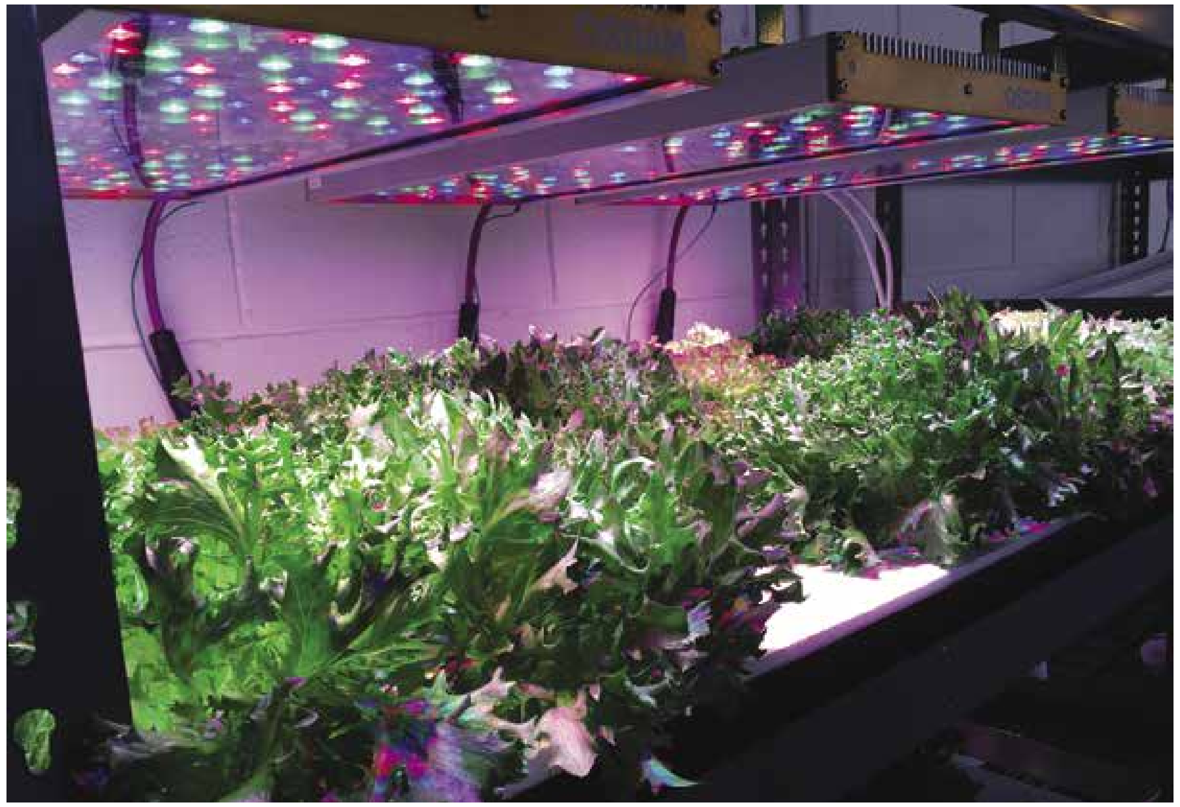
"The nice thing about growing crops in a controlled environment is that for every different parameter (temperature, humidity, CO2, water, nutrients, pH and so on), you can find the sweet spot, and with that you can influence plant growth."

An exciting area set to benefit from these grand advances in indoor growing technologies and techniques is lengthy space travel. NASA, the German space agency, and the European Space Agency are all thinking about the colonisation of Mars by 2050. But just getting to Mars and back takes three years, so learning to how grow food on the space shuttle as well as in the new colony is vital.

Using LEDs to grow plants was, in fact, an idea that originated with NASA in the late 1980s and LED research, specifically for space applications, continues today. “Much of what we’re learning about increasing the nutritional content, changing the taste, maximising yields and growing food more efficiently will translate into space travel. This is a final frontier that will enable humans to travel to, and inhabit, areas outside of Earth,” says Runkle.

Bongartz goes one step further. “Plants are not only rich, nutritious food but they also purify air and water. Plants are also connected to peoples’ mental health, so I see the psychological effect on astronauts as being important too. The act of gardening connects people to something that is living, so I think plants will play a wider role than simply creating food in future space travel, which is also true for people’s life in future mega cities on earth.”

Credit OSRAM.



Credit OSRAM.

PHYTOFY RL from Osram is a tuneable LED horticultural lighting system for research applications with real-time control and scheduling features for each individual channel.