Targeted LEDs could provide efficient lighting for plants grown in space

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Targeting hydroponically-grown leaf lettuce with red and blue LEDs saves a significant amount of energy compared with traditional lighting. Credit: Purdue University/Lucie Poulet

A Purdue University study shows that targeting plants with red and blue LEDs provides energy-efficient lighting in contained environments, a finding that could advance the development of crop-growth modules for space exploration.

Research led by Cary Mitchell, professor of horticulture, and then-master's student Lucie Poulet found that leaf lettuce thrived under a 95-to-5 ratio of red and blue light-emitting diodes, or LEDs, placed close to the plant canopy. The targeted LED lighting used about 90 percent less electrical power per growing area than traditional lighting and an additional 50 percent less energy than full-coverage LED lighting.

The study suggests that this model could be a valuable component of controlled-environment agriculture and vertical farming systems in space and on Earth, Mitchell said.

"Everything on Earth is ultimately driven by sunlight and photosynthesis," he said. "The question is how we can replicate that in space. If you have to generate your own light with limited energy resources, targeted LED lighting is your best option. We're no longer stuck in the era of high-power lighting and large, hot, fragile lamps."

One of the major obstacles to long-duration space exploration is the need for a bioregenerative life-support system - an artificial, self-contained ecosystem that mimics Earth's biosphere. A round-trip voyage to Mars for a crew of six, for example, could take about 1,000 days and would require more food, water and oxygen than current space vehicles can carry. Developing a module for efficiently growing crops would allow a space crew to grow food on long voyages and on the moon or Mars, said Poulet, now a doctoral student at Blaise Pascal University in France.

"If we can design a more energy-efficient system, we can grow vegetables for consumption for longer space travel," she said. "I can imagine a greenhouse on the moon."

The main challenge to creating a crop-growth module for space travel has been the staggering energy cost of the 600- to 1,000-watt conventional high-pressure sodium lamps traditionally used to mimic sunlight and stimulate plant photosynthesis in contained environments. The lamps also scorch plants if placed too close and require a filtration system to absorb the excess heat they create.

"Lighting was taking about 90 percent of the energy demand," Poulet said. "You'd need a nuclear reactor to feed a crew of four people on a regular basis with plants grown under traditional electric lights."

To design a more efficient system, Poulet and Mitchell turned to high-intensity LEDs, which require about 1 watt each and are much smaller and longer lasting than traditional lights. Because they emit no radiant heat, LEDs are also cool enough to be positioned close to the plant canopy and at strategic positions to maximize the amount of light that reaches the leaves.

"Instead of the minimum 4-foot separation we had between conventional lamps and lettuce, we could get LEDs as close as 4 centimeters away from the leaves," Mitchell said.

The researchers also optimized the ratio of red to blue lights, providing leaf lettuce with the best combination of lightwaves for photosynthesis and growth. Their lighting system slashed the amount of energy needed for plant growth by "an order of magnitude" compared with traditional lighting, Poulet said.

Mitchell said targeted LEDs could also help make controlled-environment agriculture on Earth more economically viable by reducing lighting costs.

The next step in research, he said, is to fine-tune when to increase and decrease lighting according to plant growth stage to optimize growing conditions and save energy.

The paper was published in *Life Sciences in Space Research*.

More information: Significant reduction in energy for plant-growth lighting in space using targeted LED lighting and spectral manipulation, www.sciencedirect.com/science/ … ii/S2214552414000327

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