Remote Source Horticultural Lighting System

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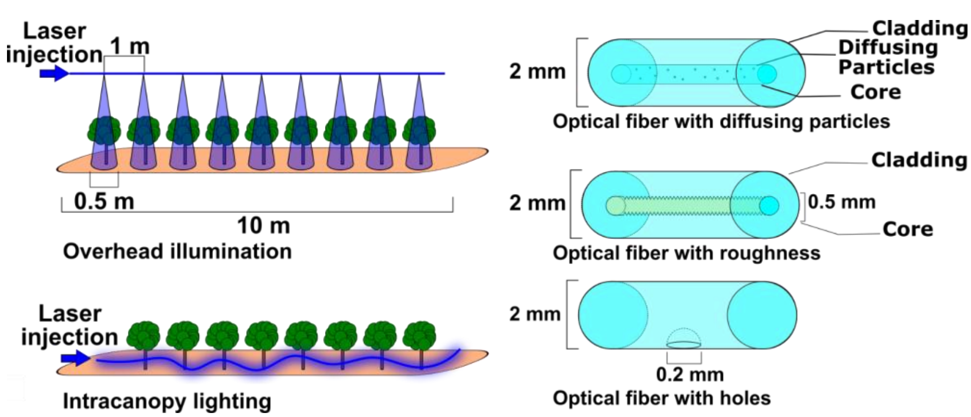
Background

LEDs have been used for horticultural lighting for several years alongside other lighting technologies such as high-pressure sodium (HPS) lamps. However, comparative studies of the impacts of various kinds of light on plant characteristics are rare. The distinguishing feature of this proposed research will come from the use of laser diodes (LDs) as the illumination source and its comparison with widely used LED lights. LDs provide orders of magnitude higher brightness than LEDs, and have a smaller form factor, enabling reduced system cost at higher illuminance, since fewer light sources are involved.

More interestingly, LDs are among the smallest light sources available and can provide a highly luminous beam with very directional emission. As a result, lasers can be coupled into waveguides and/or fibers with minor losses (as compared to LEDs), or used in combination with scanning micro-mirrors, allowing a large amount of light to be delivered from a remote source. In this manner, light can be delivered to specific plants at desired levels with limited wasted light while the temperature at the plant is kept low, preventing plants from overheating or burning. Additionally, the remote laser source can be placed outside of the greenhouse environment, removing size-constraints on the emitter and potentially increasing source reliability.

Problem Statement and Solution Concept

The primary problem to be addressed by the project is the design of a horticultural lighting system that delivers the maximum light to the plants, with maximum system efficiency, while keeping the laser source outside of the greenhouse environment. Some preliminary modeling has been done around laser coupling into leaky fiber optics and into waveguides with engineered extraction elements. Fiber optic systems have the additional advantage of allowing for light delivery around the plants instead of only via top-down illumination. However, coupling high-energy laser emission into fibers without damaging the fiber tip can be problematic. To that end, a possible solution involves leveraging free space light transmission and scanning micro-mirrors to direct light to the plants.



Fiber-guided concept

Deliverables

The team should assemble a growth system based on light delivery from a remote, multi-wavelength laser source. The team should conduct a basic theoretical study of the various options for light delivery before deciding on a system configuration (e.g. fiber, waveguide, free-space/mirrors, etc.), as well as a literature review of current LED-based approaches and their limitations.

The flux, spectrum, illumination uniformity, and temperature should all be measured at the location where the plants will eventually be placed. The system should be optimized such that there is maximum light delivered to the plant, while also maximizing uniformity and overall system efficiency (which should be calculated).

Stretch Goals

(1) Optimize the vertical density of the growth system: does a laser-based system sufficiently reduce temperature at the plant so that the light-directing element can be brought closer to the plant (essentially maximizing vertical packing density in a multi-tiered vertical farm application)
(2) Plant growth: set up a growth trial for micro-greens in an enclosed illumination system with the laser source on the outside, simulating a vertical farm

Vertical farm based on LED lighting. Can lasers enable a higher density of plants? Can lasers enable a system with fewer components?

Student Qualifications

- Interest in lasers, optics, power supplies, and circuit design
- Mechanically minded – able to work with machine shops and Innovation Workshop (makerspace)

Student Requirements

None. If interested, students are encouraged to take the idea through the TMP New Venture Competition.

Resources

Power meter:
https://www.apogeeinstruments.com/quantum/