Plants communicate what type of light they want

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Anna-Maria Carstensen and Torsten Wik in the laboratory where researchers from Chalmers are investigating how plants react to different types of lighting. Credit: Oscar Mattsson

Enormous amounts of energy are wasted in greenhouses where our food is grown as a result of the plants receiving too much and the wrong kind of light. This can also stress and damage the plants. Researchers at Chalmers University of Technology are working on a globally unique method to measure how much and what type of light plants want.

Current greenhouses use what are known as high pressure sodium lamps, which are basically the same type of lamps that are used for street lights.

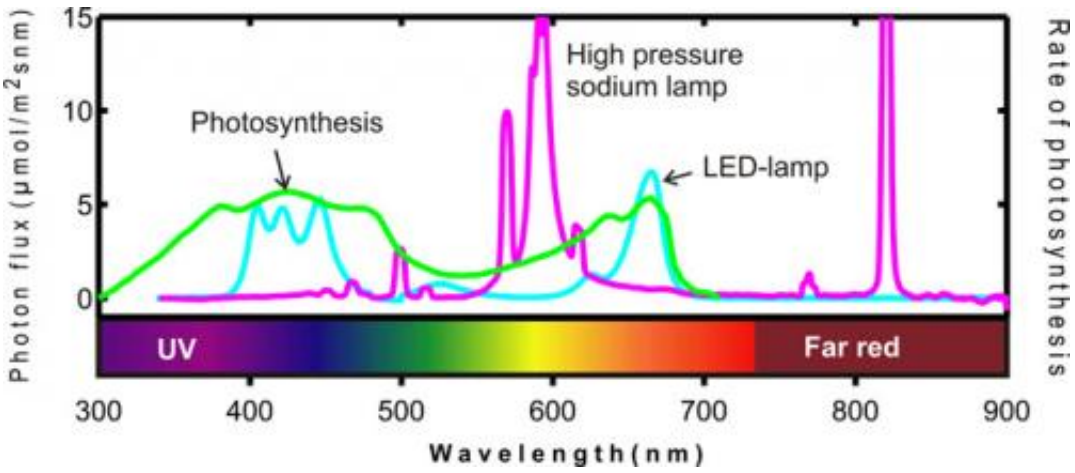
They generally only have two positions, on or off.

"Everything in modern greenhouses is very high tech except for lighting," says Anna-Maria Carstensen, who is a PhD student in automatic control at Chalmers. "Temperature and nutrition are meticulously controlled. Lighting regulation, however, lags far behind."

The light spectrum provided by high pressure sodium lamps corresponds very poorly to the spectrum plants use during photosynthesis (see image). Plants do not receive very much of the blue and red light that they need the most. They do, however, receive a great deal of infrared light, which is harmful to some crops, and yellow light, which the plants cannot utilize to any great extent.

Researchers interpret plant signals

The research project at Chalmers aims to ascertain how much and what type of light different plants require at specific times. In the development of the method a spectrometer is used to measure which wavelengths are sent back by the plants. The plants send back light in two different ways:



The diagram shows: 1. How the efficiency of photosynthesis depends on wavelength (green). 2. Wavelength content for regular sodium lamps (pink). 3. Wavelength content for an advanced LED lamp (turquoise). Credit: Torsten Wik

- Direct reflection, where the light bounces back without being absorbed by the leaf.
- Fluorescence, which is light emitted by plants. This light is created by photosynthesis and consists of wavelengths other than those from the supplied light.

Researchers can analyse these signals to determine which light plants require. The image below is an approximate diagram of photosynthesis. In reality, there are great variations depending, for example, on which plant it is, where the plant is in its development cycle and how warm it is.

"This is uncharted territory," says Torsten Wik, associate professor of control engineering and head of the research project. "How plants react to light is generally determined by taking manual samples on or close to leaves using special equipment. We perform the analysis remotely, however, using the lamp's control options. This means that an entire plant population can be measured, which automatically enables a representative average for the kind of light they need."

Plants' response will control lighting

The project's aim is to produce a system that employs the plants' response to automatically regulate the lights in the greenhouse. Natural sunlight can then be supplemented with light from lamps to ensure the total lighting is that required by the plants, both in terms of brightness

and light spectrum.

This can be achieved using advanced LED lamps, which consist of several groups of dimmable light emitting diodes with different colour spectra. This kind of lamp can also be programmed to provide lighting that is adjusted to the needs of the plants.

"The technology has enormous potential for energy savings," says Torsten Wik. "We are counting on being able to save about 30 per cent by switching from sodium lamps to LED. Furthermore, it is possible to save 20 per cent by regulating the light's intensity and spectrum using our method. This means that greenhouses in Europe alone would be able to save as much electricity as half of Sweden's electricity consumption."

Facts: The method offers several potential environmental advantages

- Half the regular energy consumption. Greenhouses in Europe consume as much electricity as Sweden does as a whole, which is 160 terawatt hours a year.
- Reduced need for chemicals in greenhouses. Chemicals are currently used on many plants to keep them compact and prevent them from growing too tall; the same effect can be achieved using the right light spectrum instead. The taste and sustainability of crops can also by influenced by using light.
- Reduced amount of waste in commercial greenhouses. About 15 per cent is currently discarded since production is sometimes greater than what can be sold. Utilisation of lighting can both slow down and speed up plant growth when necessary.
- As opposed to high pressure sodium lamps, LED lamps do not contain mercury.

Provided by Chalmers University of Technology