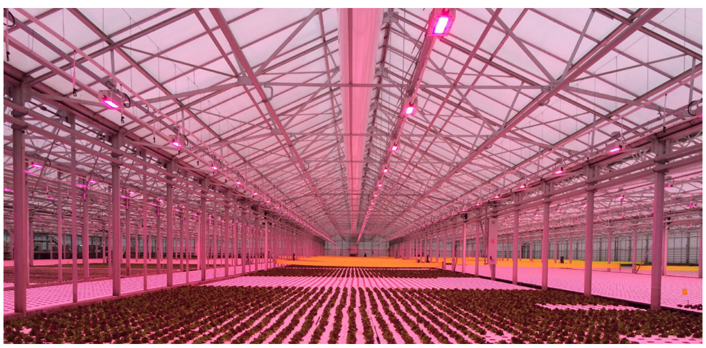
GLASE Technical Articles Series

GLASE

Consistent Crops Require Consistent Light

by Tim Shelford, Kale Harbick Melissa Brechner, Louis Albright and Neil Mattson

In commercial greenhouse production, the KEY to acquiring and retaining long-term customers involves ONE simple concept: Produce a consistent, high-quality crop at a predictable and steady rate, 365 days per year.



GLASE commercial pilot greenhouse, SAF Produce (Berlin, NY) utilizing LASSI control.

To meet this goal you need to grow the same amount of saleable product every day and the key to this is to control the total amount of light plants receive. More than any other environmental variable, the total sum of light received by the plants in a 24-hour period determines the rate that plants grow and thus the amount of produce available for sale. And light is the one environmental parameter that can vary up to ten-fold during the year. We have found that the major customers of commercial production facilities will not accept decreased production in the winter due to poor natural growing conditions nor will they accept produce that has been damaged by too much light during the summer.

Plant vegetative growth is proportional to the light integral over a plant's growth period, and consistent growth timing can be achieved only by providing plants the same light integral every day (Daily Light Integral, DLI). Nature does not provide consistent DLI values, as shown in **Figure 1** (typical uncontrolled DLI within a greenhouse with 70% transmissivity, in Ithaca, NY.) When plants are grown in a greenhouse, the DLI is the sum of natural (sun) light, as well as supplemental light used on darker days. Movable shades must also be considered to prevent over-shooting the DLI goal, which can cause physiological disorders such as lettuce tip burn, as well as providing less predictable crop timing. These needs motivated creation of a control algorithm that can forecast the total solar (natural) DLI for a day, and then operate supplemental lights and movable shades in a way that achieves the DLI goal every day. This Cornell developed control algorithm is called LASSI, (Light and Shade System Implementation).

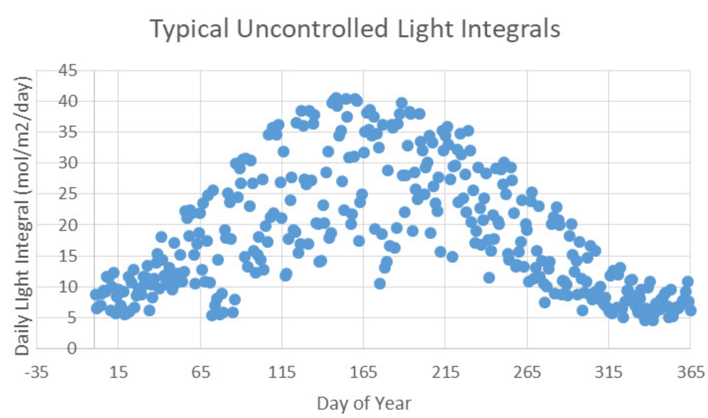


Figure 1: Typical Uncontrolled (no supplemental lighting or shades) Daily Light Integral within a greenhouse located in Ithaca, NY with a transmissivity of 70%.

Another goal of the control algorithm is to reduce the cost of operating supplemental lights by shifting lighting to off-peak periods of the day when the cost of electricity is lower. In addition, LASSI, delays lighting as much as possible early in the day to prevent overlighting and requiring the shades to deploy later in the day, thus decreasing dramatically the amount of wasted supplemental light.

The LASSI algorithm contains a supplemental lighting module and a shading module, and makes decisions on a one-hour time step. The lighting module is a series of eight rules, based partly on a prediction of solar DLI by sunset, which determines whether supplemental lights should be operated starting immediately, or whether lighting can be delayed for at least one more hour. The shade module consists of two rules that determine whether shades must be closed immediately, or whether deployment can wait until the next hour. As shown in **Figure 2**, control is very consistent during darker times of the year, when supplemental lighting can be used during the day and at night. During brighter times, occasional small daily overshoots occur. However, adjusting the DLI target down to account for previous days overshoots, can bring three-day averages very close to the DLI goal, and plants respond suitably to three-day averages.

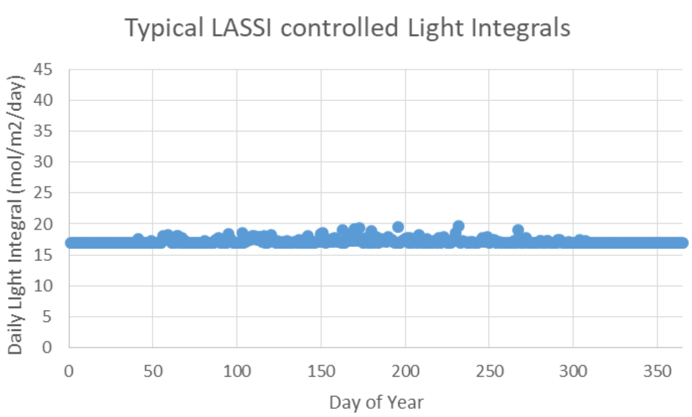


Figure 2: Typical LASSI controlled (with 180 umols/m2/s of supplemental lights, and a 50% shade curtain controlled by the LASSI algorithm) Daily Light integral, within a greenhouse located in Ithaca, NY, with a transmissivity of 70%. The target DLI was 17 mol/m2/d.

In addition to providing consistent, predictable year round production, LASSI has also been demonstrated to reduce the energy use of a greenhouse when compared to other supplemental light control strategies such as threshold control (turning the lights on/off when natural light is below/above set targets). LASSI can provide lighting energy savings of up to one-half in climates such as upstate New York. Over a year, the electricity savings can be nearly four dollars per square foot, or 40 kWh per square foot-year.

Since the original development of the LASSI algorithm, further research has included expanding its functionality to include other crops beyond lettuce such as other leafy greens, as well as fruiting crops such as tomato and strawberry. The control algorithm has also been updated to include the option of requiring a night break (for photoperiodic crops). LASSI has also been expanded to take advantage of CO_2 supplementation to further reduce supplemental light costs.

LASSI is still being improved and adapted to take advantage of new technologies and expanding the library of crops with which it has been tested. Current GLASE research projects at Cornell are focused on adapting LASSI to work with Day Ahead Market Pricing (where utilities publish the hourly cost of electricity for the next day), using dimmable LEDs and plant response monitoring equipment to avoid oversaturating the crop, and developing CO_2 response curves for additional crops.

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To find more about GLASE please visit glase.org or contact GLASE executive director Dr. Erico Mattos at em796@cornell.edu

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