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New Web-Based Supplemental Light Calculator (DLICALC)

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If you measure light in your greenhouse, you probably use instantaneous values such as foot candles (f.c.) or lux. Unfortunately, these two units are only a measure of light visible to the human eye. As greenhouse growers we are interested in measuring photosythetically active radiation (PAR), the light our plants utilize for photosynthesis, in micromoles ($\mu mol \cdot m^{-2} \cdot s^{-1}$). But, this is still an instantaneous reading and, as we all know, light levels are constantly changing. Research at Purdue and other universities is showing the economic benefits of monitoring and managing the cumulative amount of photosynthetic light that is received in a greenhouse over the course of a 24 hour period, which is known as the daily light integral (DLI). For example, this greenhouse operation has placed an excessive amount of fern hanging baskets above their bench top crops resulting in a sub-optimal DLI at bench height (Figure 1). One question we are often asked is: "How do we calculate DLI?" Calculating DLI can be a daunting task.

We created a decision support tool, DLICALC (http://extension.unh.edu/Agric/AGGHFL/dlicalc/index.cfm) as a tool to help growers manage the photosynthetic light environment. You may already be familiar with the GROCALC

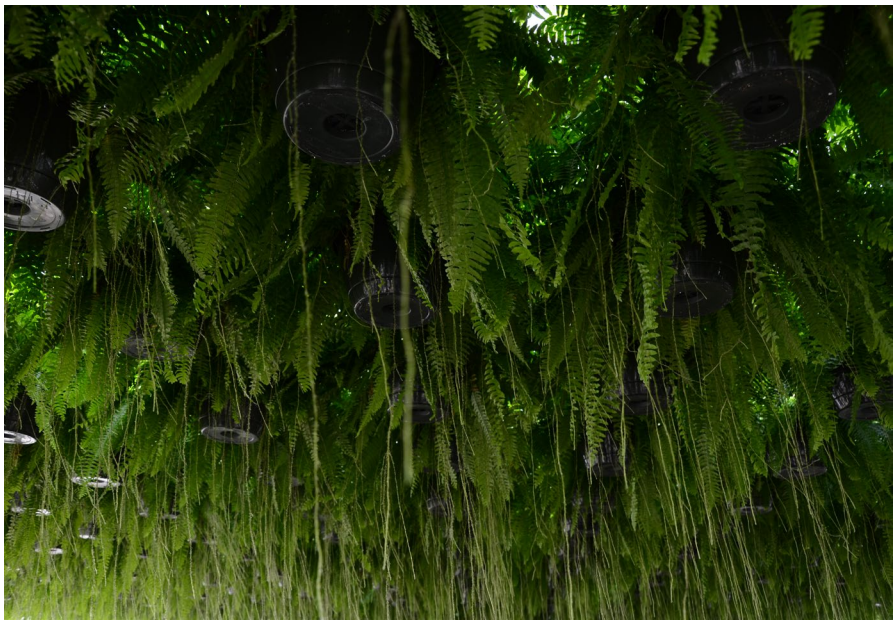

Figure 1. A greenhouse with excessive hanging baskets suspended above other crops often results in a sub-optimal daily light integral at bench height.

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suite of electronic grower decision support tools that include ALKCALC, FERTCALC, and PGRCALC (Figure 2). These programs are useful for making calculations related to greenhouse crop culture including water acidification requirements, fertilizer solution, and plant growth retardant (PGR) mixing. However, there are few or no tools available to help make calculations related to the greenhouse environment.

Figure 2. DLICALC is the newest calculator in the GROCALC family of electronic decision-support tools for greenhouse growers interested in managing the daily light integral in their greenhouses.

In cooperation with our local and state greenhouse organizations

DLICALC functions

The main function of DLICALC is to calculate the answer to two different questions:

1) "I currently have supplemental lights [high pressure sodium (HPS) or metal halide (MH)] in my greenhouse. How long do I need to run them to achieve a target supplemental DLI?" For example, a young plant grower has HPS lamps that provide 60 $\mu mol \cdot m^{-2} \cdot s^{-1}$ (554 f.c.) at plant height. They would like to increase their DLI by approximately 4.5 $mol \cdot m^{-2} \cdot d^{-1}$, but are unsure how long to operate the lamps for.

or

2) "I am currently operating supplemental lights, what is my supplemental DLI?" For example, a bedding plant grower has MH lamps operating from 6 to 10 am and from 4 pm to 12 am (12 total hours of operation) providing 55 $\mu mol \cdot m^{-2} \cdot s^{-1}$, but would like to know how much of their total DLI is from supplemental light.

To answer these questions, DLICALC is designed to:

1) estimate a supplemental DLI from your supplemental light source

2) estimate hours of lamp operation to achieve a target supplemental DLI (Figure 3). In order to determine how long to operate supplemental lights each day to achieve a target DLI, the target supplemental DLI,

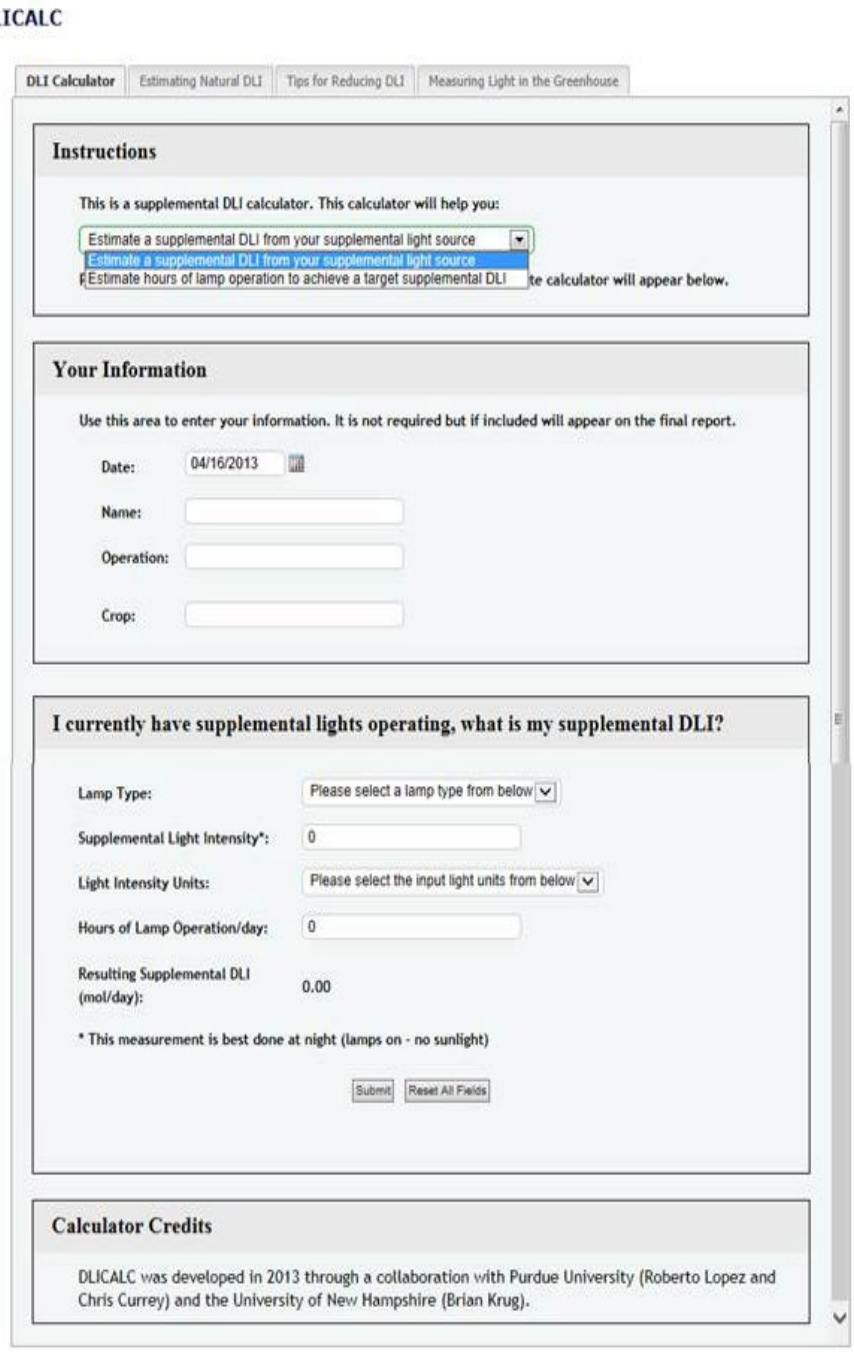

Figure 3. The central feature of the DLICALC is to calculate either the amount of supplemental photosynthetic light provided by an existing program or the amount of time required to operate an existing supplemental light source to achieve a target supplemental daily light integral.

lamp type (i.e. HPS, MH, etc.), supplemental light intensity value and the corresponding unit of measurement (i.e. f.c., $\mu mol \cdot m^{-2} \cdot s^{-1}$) must be entered into the program. Note that converting f.c. to $\mu mol \cdot m^{-2} \cdot s^{-1}$ and vice versa requires a specific conversion factor that DLICALC integrates into its calculations for different light sources. From this information, the number of hours needed to operate supplemental lights is calculated. So for our young plant grower in the example above, the HPS lamps would need to operate for approximately 21 hours to provide 4.5 supplemental $mol \cdot m^{-2} \cdot d^{-1}$. Alternatively, to determine the amount of supplemental light provided by an existing supplemental lighting program, the lamp type, supplemental light intensity and the corresponding unit of measurement, and hours of operation must be entered and, from this, the supplemental DLI is calculated. Again, for our bedding plant grower above, when they operate their MH lamps for 12 hours they provide 2.4 $mol \cdot m^{-2} \cdot d^{-1}$ of supplemental light.

Other DLICALC functions

While the main function of DLICALC is to help manage supplemental lighting, there are several other factors that contribute to the greenhouse light environment. In addition to calculating supplemental DLI and hours of lamp operation, DLICALC contains information on measuring light in the greenhouse and estimating the natural DLI, as well as tips for using shade in the greenhouse.

One of the most important aspects of photosynthetic light management is successfully measuring the light in your greenhouse. However, there are several things to consider in order to record accurate light measurements. For instance, type of measurement (instantaneous versus cumulative), sensor type and calibration, and sensor placement and cleanliness all impact light measurements. In DLICALC, we provide some basic guidelines, resources, and supplemental materials to assist growers in measuring photosynthetic light in the greenhouse.

Measuring photosynthetic light in a greenhouse is the only way to accurately know what the environment in your greenhouse is. We provide a description of light units and terminology and present several publications dedicated toward better understanding measuring and quantifying the light environment in greenhouses. However, we know that not everybody will have access to some of the tools necessary to measure ambient light. Therefore, we discuss the nature of light transmission of outdoor light into a greenhouse and present monthly outdoor DLI maps developed at Clemson University.

Although many growers are concerned about increasing the DLI in greenhouses, it is also common to reduce the DLI when ambient light is high or when low-light crops such as phalaenopsis orchids are being produced. One of the features of DLICALC is a page dedicated to best management practices and shading.

Conclusions and Future Directions

The ultimate goal of DLICALC is to enable growers to better manage supplemental lighting and greenhouse light in general. We hope that DLICALC will be a useful tool for growers to help manage the photosynthetic light in the greenhouse, as well as other aspects of managing the light environment. While DLICALC will not have the ability to tell a grower exactly what the total DLI (ambient solar + supplemental) is, we hope that it will be a step in the right direction of having greenhouse growers make informed decisions when managing photosynthetic light.