Plant Growth and Morphology Under a Sky Color Light Program

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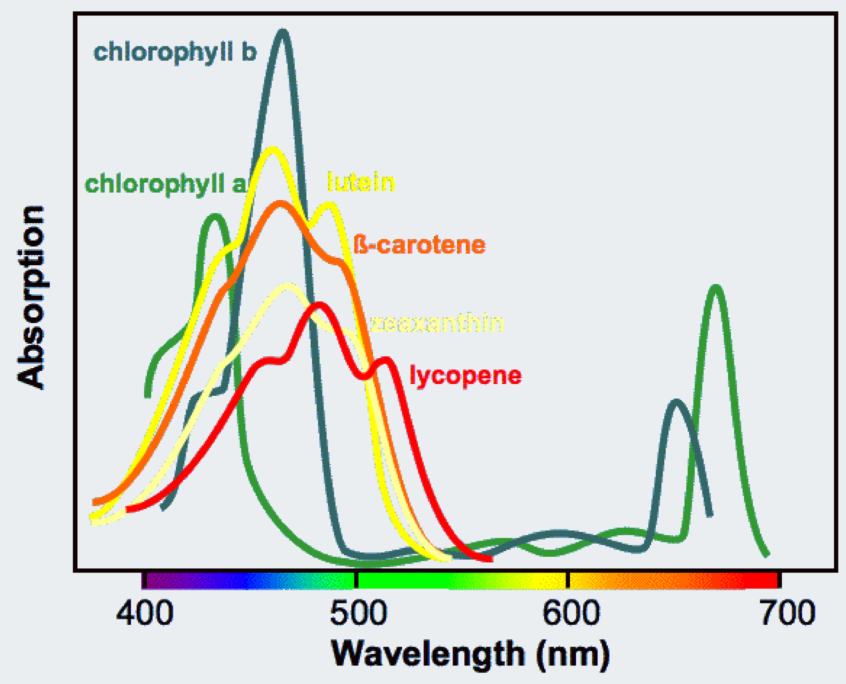
We describe our developing investigation to observe the developmental characteristics of plants grown under a LED light regime that mimics the daily sky color cycle. Previous research has investigated sequential treatments of darkness, blue light, green light, red light, and infrared light to significantly alter final product quality[1,2]. We hypothesize that there will be a quantifiable difference in growth habits and characteristics between plants grown with LEDs under a sky-mimicking light pattern and plants grown with LEDs under a constant light schedule.

These ongoing efforts seek to investigate growth characteristics for a variety of agricultural plants, which will provide insight into improving cultivation techniques on Earth as well as in artificial environments such as space stations. Future work will extend this analysis to examine the dependence of plant growth on the stellar spectrum by examining differences between blackbody, solar (G-type), and non-solar (F/K/M-type) spectral energy distributions.

Light Color and Plant Growth

Light is the primary energy source for nearly all life on Earth. Photosynthetic organisms rely on light-harvesting pigments to absorb this energy and convert it to chemical energy that can be stored for later use. Early research into plant photosynthesis has shown that plant morphology and growth characteristics are directly influenced by the spectral quality of the light source illuminating the plants[3]. Further studies have revealed that while individual pigments typically have narrow peak-efficiency ranges, competition for light has led to the evolutionary development of numerous pigments, which allow greater light energy to be collected across the broad radiation spectrum of the Sun[4]. This insight, and the desire to attain the maximum growth, have been the basis for the development of more efficient plant grow light systems.

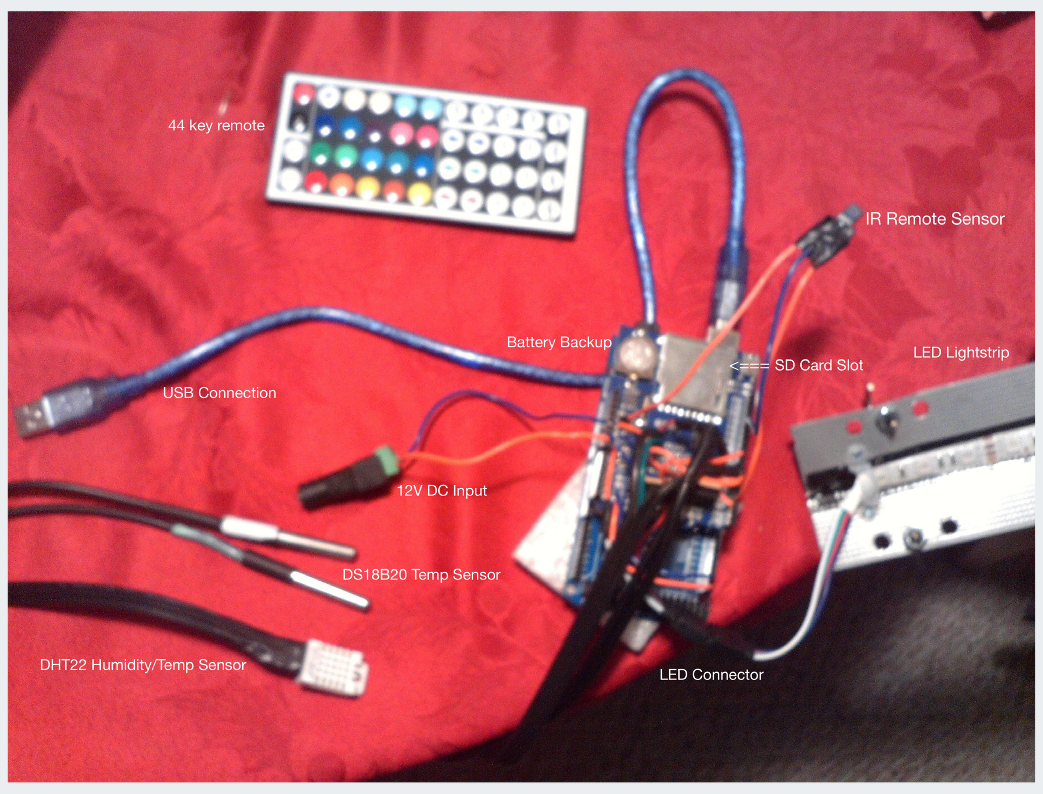
The photosynthetic pigments absorb much of the spectrum



Open Source LED Technology

Conventional grow lamps such as high-pressure sodium, metal halide, or compact fluorescent output "full-spectrum" light, as well as heat, over a large area. By contrast, light emitting diodes (LEDs) produce a discrete band of visible light and minimal heat from a surface that is only a few millimeters across. Prior to the availability of LED technology, it was highly impractical to make fine adjustments to transmitted light over small fluctuations in time. However, computer controlled, wavelength-specific LEDs have given researchers precise control over the lighting environment. Red, Green, Blue (RGB) LEDs combine each color diode into a single package that can provide "white" light when all three of its diodes are lit. Additionally, the intensity of each color can be adjusted independently to provide any color in between. The greater availability, decreasing cost, and improved efficiency has increased the popularity of LEDs as an artificial lighting source.

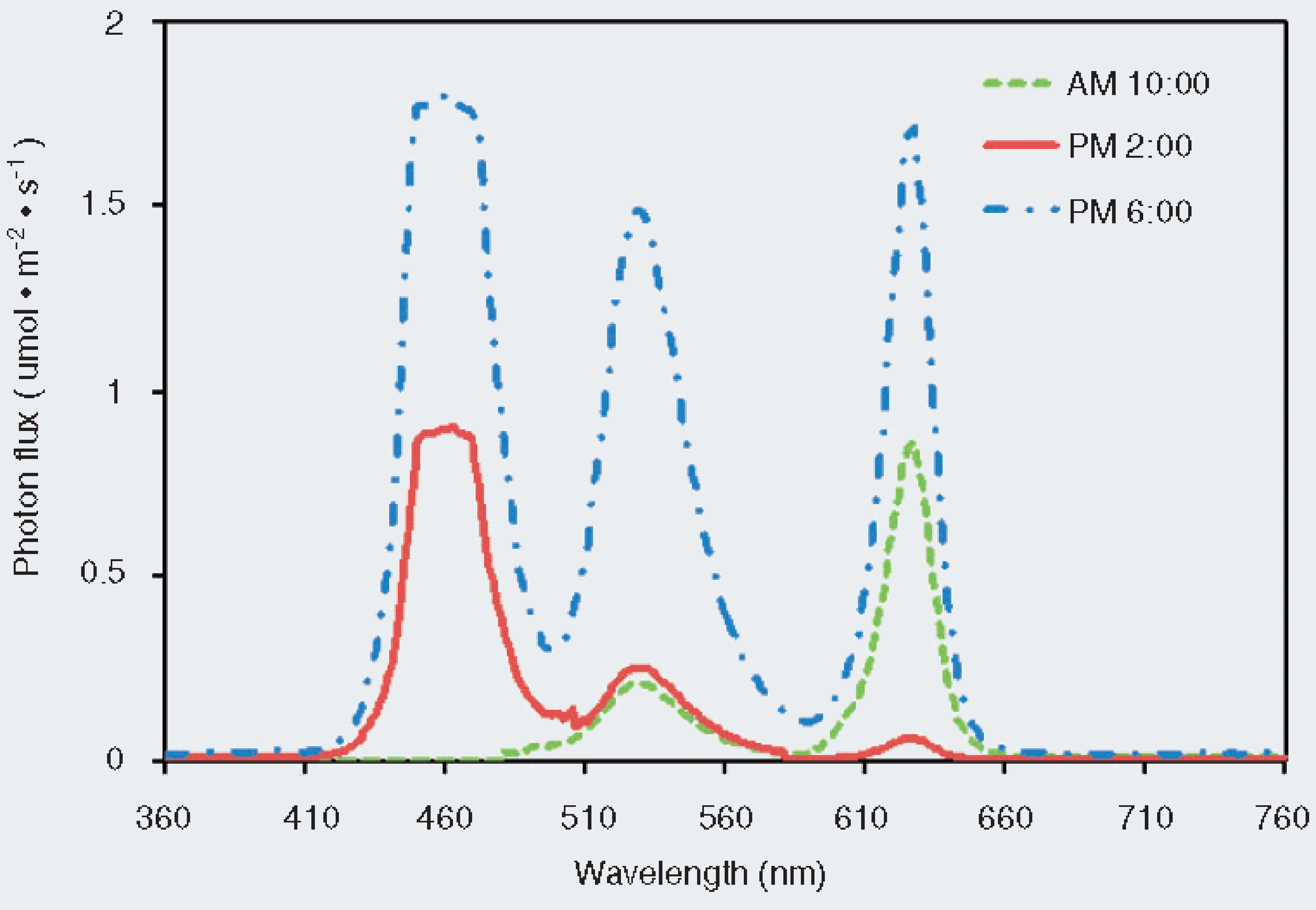
We use an Arduino© microprocessor board to control our LED arrays. Arduino© is an open-source prototyping board based on the C++ programming language. The code will utilize data from a real time clock (RTC) and the sun's position based on physical longitude and latitude to calculate a matching RGB value. This serves as a realistic daily light cycle that transitions from a pre-dawn to dusk, which provides a realistic color profile for plant growth.



Sky Color Light & Space Exploration

Our development of a realistic sky color light program will focus on application to the growth of microgreens. Microgreens are the first pair of young true leaves to sprout from a seed and are considered a culinary delicacy by many chefs. Moreover, microgreens offer a 2-3 week turnaround time between planting and harvesting, which make them an ideal candidate for experimenting with different light color programs. Our initial experiments involve sunflower and snow pea microgreens, although we intend to extend these trials to include other microgreen varieties, as well as herbs and lettuces.

These experiments also aim toward the level of understanding required for the cultivation of produce for future long-term space missions. LED technology provides many of these benefits for the needs of space travel[5], and our ongoing trials with light programs for microgreens and other crops will increase our knowledge of the dependence of plant growth on spectral variability.



An existing fuzzy logic-based supplementary light spectrum for Red, Green, and Blue light at different times of day[6].

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