Increasing Blue Light from LEDs Reduces Leaf Length in Kale

URCO Final Report

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Abstract

Over the last few decades LEDs have become more common in plant research for NASA and as supplemental lighting sources for greenhouse commercial production. This has raised many questions about their efficiency and their effect on plant growth. Research has shown that a combination of red and blue light or broad spectrum LEDs are the most effective at driving photosynthesis in most crops. Historically, green light has been believed to be less effective at driving photosynthesis, however recent studies suggest that green light added to red and blue light can increase plant biomass. The purpose of this study is to determine the effects of different ratios of colored LEDs on kale growth (fresh mass, dry mass, and leaf area) by growing plants under fractions of red, blue and green light at two different levels of total photosynthetic photon flux. This study will increase our understanding of how LED colors affect growth and development of kale and provide critical information for greenhouse crop production in which kale is valued for its high nutritional content. This research will also be important for NASA where LEDs are being considered for future long distance space travel in which food production and energy efficiency were be an issue.

Hypothesis

Hypothesis One:

Increasing fraction of blue light will decrease whole plant growth.

Hypothesis Two:

Increased fraction of blue light will decrease whole plant photosynthesis.

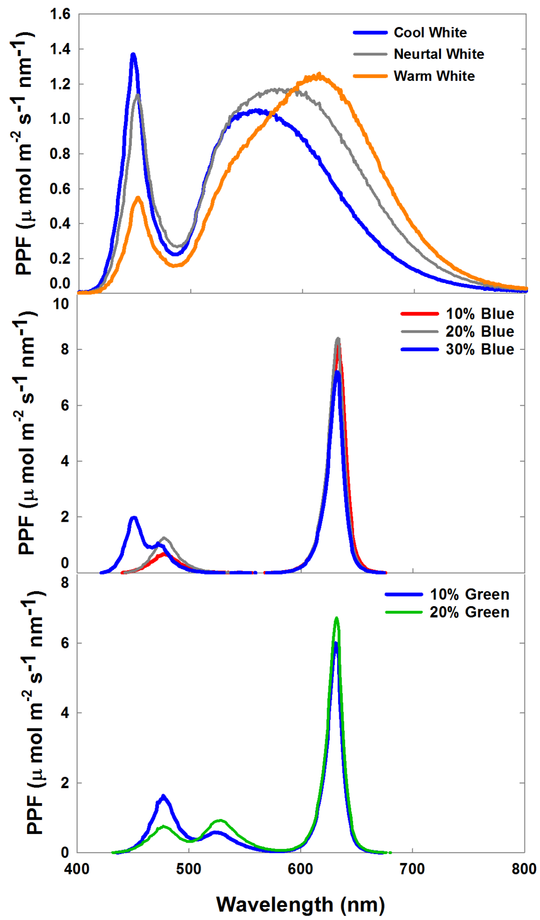
Hypothesis Three:

There will be an interaction between light quality (color) and light quantity (intensity).

Materials and methods:

The system included 16 chambers: eight treatments at low PPF (200 $\mu mol\ m^{-2}\ s^{-1}$) and eight at high *photosynthetic photon flux* (PPF) (500 $\mu mol\ m^{-2}\ s^{-1}$). PPF was measured using a quantum sensor at the top of the plant canopy and adjusted to keep variability within each growth chamber below 2%.

% Blue Light	10	10	11	19	20	20	27	30
% Green Light	0	20	41	46	0	10	48	0
%Red Light	90	70	48	45	80	70	25	70



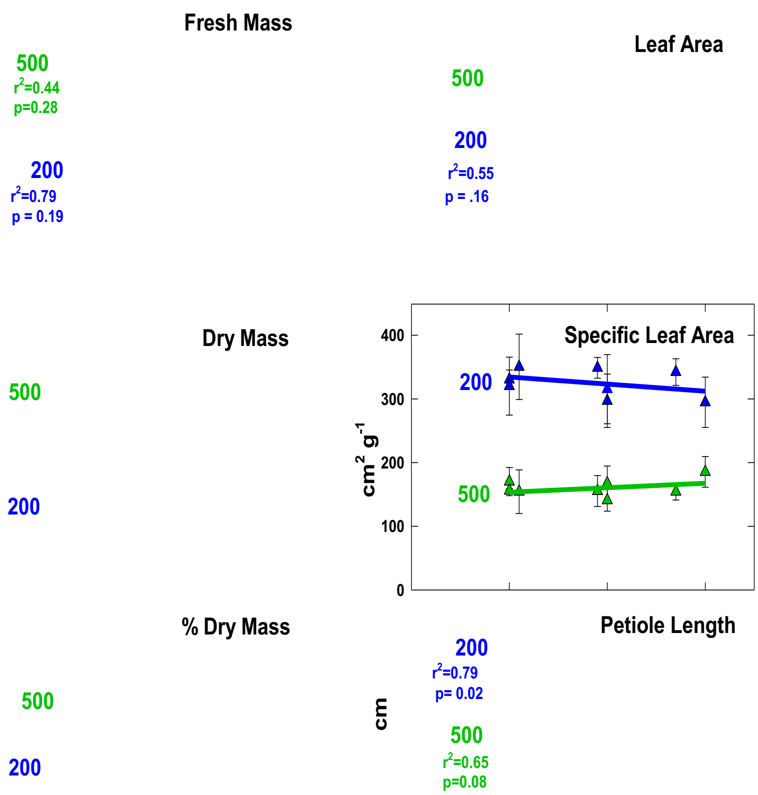
The percentages of blue, red and green light in each of the eight chambers shown above were replicated at each high light level.
Spectral distributions of each chamber where taken using a spectroradiometer. These readings where used to calibrate each of the chambers to the percentages of light colors listed above.1810

Plant Material and Cultural Conditions

Kale seeds were pre-germinated until radicle emergence. After emergence the four most uniform seeds were be transplanted into root modules measuring 15 x 18 x9 cm (L x W x H; 2430 cm^3). Root modules were filled with horticultural grade soilless media (one peat: one vermiculite by volume). Five grams of slow-release fertilizer Nutricote (16N-2.6P-11.2K) were uniformly mixed into the media. Root module were then randomly placed into one of the 16 LED chambers. After planting root modules were watered to excess using dilute fertilizer (0.01N-0.001P-0.008K; Scotts Peat-lite, 21-5-20; EC=100 mS m) solution, and allowed to passively drain. Growth chambers measure 20 x 23 x 30 (13800 cm^3). The walls of each growth chamber are lined with high-reflectance Mylar, which were to help contain the light within the chamber. Thermocouples connected to a data logger were used to continuously monitor temperature, at the top of the plant canopy.

Plant Measurements

At harvest, stem and leaf fresh mass were recorded as well as the total leaf area. The number of leaves per plant were be counted and the petiole length were measured. The plants were then dried for 48 h at 80 C to determine dry mass. The data was collected and analyzed.



Conclusions

Of all the parameters tested, only leaf length was affected significantly with increasing blue light. There was no significant effect on fresh or dry mass, percent dry mass, leaf area or specific leaf area.

Kale is less sensitive to blue light than lettuce, tomatoes and radishes but kale is more sensitive than wheat (Snowden et al, 2016**).**

References

Cope, Kevin R., and Bruce Bugbee.(2013) *Spectral Effects of Three Types of White Light-emitting Diodes on Plant Growth and Development: Absolute versus Relative Amounts of Blue Light*. *HortScience* 48.4: 504-09.

Cope, Kevin R., M. Chase Snowden, and Bruce Bugbee. (2014) *Photobiological Interactions of Blue Light and Photosynthetic Photon Flux: Effects of Monochromatic and Broad-Spectrum Light Sources. Photochemistry and Photobiology* 90 : 574-84.

Snowden MC, Cope KR, Bugbee B (2016) Sensitivity of Seven Diverse Species to Blue and Green Light: Interactions with Photon Flux. PLoS ONE 11(10): e0163121. doi:10.1371/journal.pone.0163121

Impact Statement:

During the course of this project I was able to gain many useful experiences, including basic electrical skills, how to run a successful experiment, a great understanding of the scientific process. I was able to get out of my comfort zone and try new things that I had no idea that I was capable of.

Before beginning experimentation, I had to redesign the growth chambers to produce the spectral output necessary for this experiment. I had never had much experience with electronics. Now I am comfortable using power supplies, current controllers, and even wiring LEDs. This experience was very beneficial over the course of my whole project as I was able to troubleshoot any problems with the chambers.

An experiment always seems to go better on paper than it does when actually accomplished. There were a few struggles that I ran into during the course of my project. Sometimes things did not go as expected. This experiment taught me to be flexible and “roll with the punches”. With each challenge there was also a learning opportunity and in the end everything worked out well.

I was honored to present my research at the International Plant Propagators Society meeting this October in Phoenix, Arizona. It was an incredible experience to share my knowledge and conclusions with people currently working in crop production

This experiment taught me that science truly is a process. It seems that the more questions we answered the more questions I had. This inspired me to once again apply and receive funding through an URCO grant so that I may continue to pursue this interest in my project.

I believe that the experiences I received through this project will continue to help me in the future as I pursue a career in plant science. Learning to research is a valuable skill that I would not have gotten any other way. I am extremely grateful for this experience.