Management of LED Light Quality to Maximize Biomass and Chlorophyll Fluorescence in Sprouting Broccoli in Controlled Environments

Rosalie M. Metallo[1*], Dean A. Kopsell[1], and Carl E. Sams[1]

[1] Plant Sciences Department, The University of Tennessee, Knoxville, TN.

Introduction

Aside from being an important energy source for photosynthesis, light regulates the photomorphogenesis, or the light-dependent growth response, of all plants (1,2). Specialized protein-pigments absorb light energy within the visible light spectrum (400nm-790nm), as well as in the UV and infrared spectrums, to activate developmental pathways or signal physiological changes (3,4). Light emitting diodes (LEDs) allow for the targeting of wavelengths to complement specific light-signaling pathways and increase photosynthetically active radiation (PAR) efficiency (5).

While current LED studies focus on investigating photomorphogenesis and photosynthetic pathways, very little information is available on the impacts of LED supplemental lighting on commercially important factors for specialty crops in controlled environments.

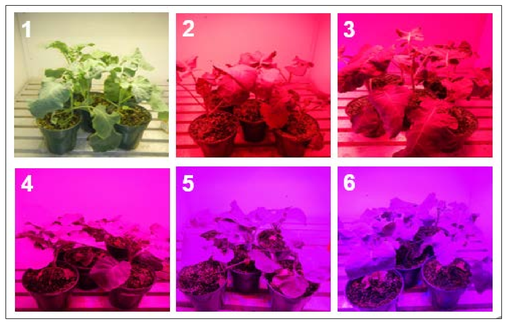
Materials & Methods

Plant Culture

Sprouting broccoli (*Brassica oleracea* var *italica*) were seeded into soil-less media under greenhouse conditions and transferred to growth chambers 7 days after seeding (DAS). Sole source LED treatments were: 1) white; 2) 5% blue (447 nm) / 95% red (627 nm); 3) 10% blue / 90% red; 4) 20% blue / 80% red; 5) 40% blue / 60% red; and 6) 60% blue / 40% red (see below). The experiment was repeated three times. All plants were harvested 30 DAS.

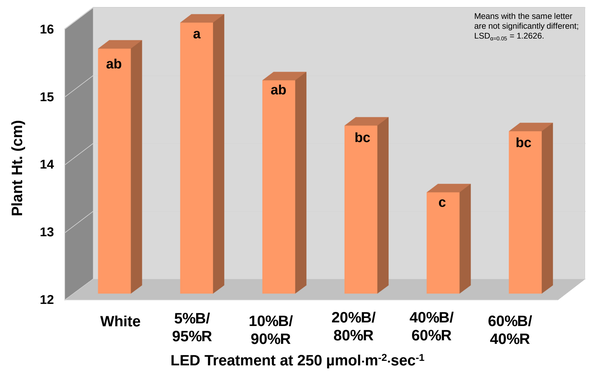
Data Collected

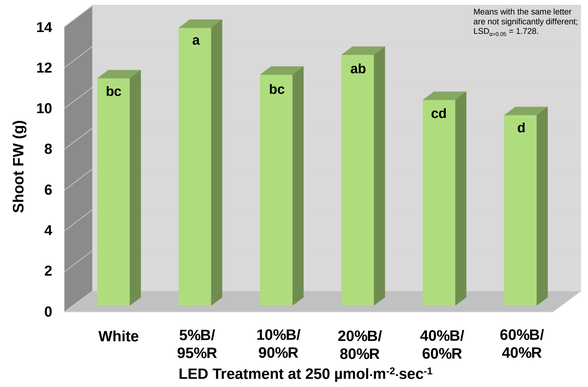
Plant biomass parameters were collected at the time of harvest. Height (cm) and shoot tissue fresh weight (g) were measured. Chlorophyll fluorescence measurements were collected using a hand-held fluorimeter (OS3p, OptiSciences, Hudson, NH). Data were analyzed in SAS using Least Significant Difference (LSD) and Duncan's Multiple Range statistical tests (9.4, GLM).



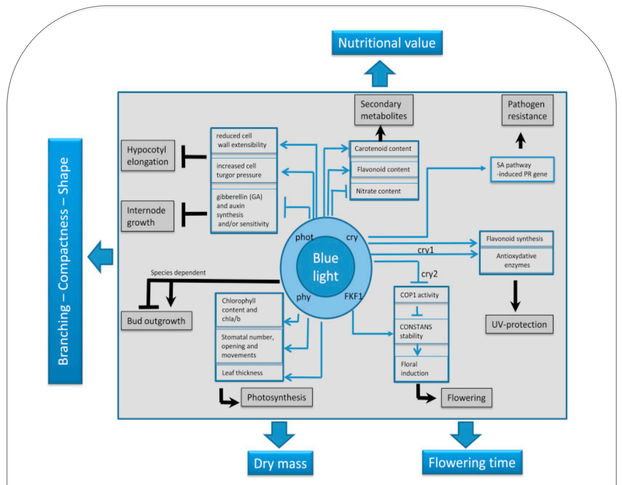
30-day old Sprouting broccoli grown under LED lighting in controlled environments with a 14-hour photoperiod and a light intensity of 250 µmol·m^{-2}·sec^{-1} for all treatments.

LED Treatments Impact Plant Height and Biomass



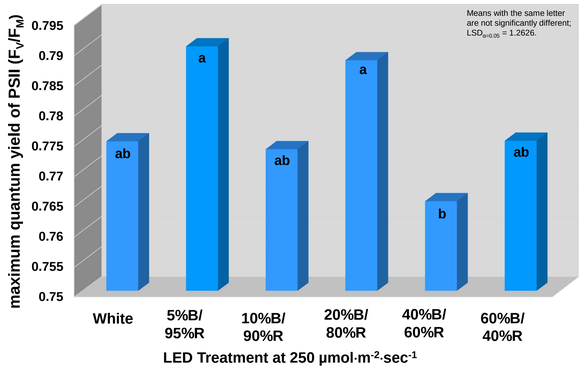


Broccoli plant height (P≤0.001) and shoot fresh mass (P≤0.001) varied in response to light quality treatments. The height of Sprouting broccoli was significantly decreased under 40%blue/60% red as compared to all other narrow-band LED light treatments, while an increase in plant height was observed in the 5% blue/95% red LED treatment. The 5% blue/95% red LED treatment resulted in higher shoot tissue fresh weight (FW) as compared to the 40%blue/60% red and 60%blue/40% red.



Physiological processes (blue square) and **developmental phases/responses** (grey square) in plants after manipulation in a blue light environment. Taken from Huché-Thélier et al., 2016.

LED Treatments Impact Chlorophyll Fluorescence



The maximum quantum yield of PSII (F_V/F_M; P=0.02) was influenced by LED light treatment. The 5% blue/95% red and 20% blue/80% red LED treatments resulted in significantly higher F_V/F_M than all other LED treatments, whereas 40%blue/60% red LED treatment produced the lowest F_V/F_M values compared to all other treatments.

Conclusions

Sole source 5% blue/95% red LED lighting resulted in the highest plant growth and fresh shoot weight as compared to all other LED treatments. Photoreceptor regulated hormones are known to trigger physiological response pathways in the presence of varying light quality to elicit stem elongation or shortening, branching, flowering, UV protection, secondary metabolite concentrations, and photosynthesis (6,7,8). LED lighting is an emerging area of controlled environment horticulture; however, more information is needed on the impacts of narrow-band wavelengths on biomass and physiological processes in specialty crops.

Literature Cited

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