Combined Proceedings IPPS 73:20-25. 2023.

Effects of Blue Light and Cultivar in the Internode Elongation in Sweet Basil

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Keywords: LED, *Ocimum*, plant height, light quality

Summary

Two sweet basil F_1 cultivars, 'Campione', a tall Genovese type, and 'TSGI-156', a short Italian large-leaf type, were used to investigate the effect of light quality on the internode elongation using a mixed white LED light (blue: 470 nm, green: 530 nm, red: 630 nm, 1:1:1 mix ratio) and a monochromatic blue LED light (peak wavelength: 470 nm). Plant height and internodal length above the second node were higher and longer under the blue LED for both cultivars. The effect on internode elongation was greater for 'TSGI-156' than for 'Campione'. Cortex cells were larger under the blue LED, and in 'TSGI-156', the long axis length of cells under the blue LED was about 60% longer than that of the white LED. Blue light has been reported to have an inhibitory effect on plant stem elongation, but in sweet basil, it was found to have a promotive effect.

INTRODUCTION

Plants need light not only for photosynthesis, but for regulation of their growth and development. In recent years, the effects of light quality have been studied for effective plant production with artificial light (Brian, 2006; Massa et al., 2008). Stem elongation is one of the most important plant characteristics in horticultural production, used in the production of graft and compact seedlings. Previous studies have indicated that blue light was more effective than red light in suppressing stem elongation in many species (Laskowski and Briggs, 1989; Shimizu et al., 2006). However, its effects have also been reported to vary with species, light intensity, and blue/red ratio (Hirai et al., 2006; Nanya et al., 2012). In sweet basil, the lower internodes of seedlings grown under blue light elongated (Amaki et al., 2012.). However, basil seedlings tested in Amaki's experiment showed variation in plant height immediately after germination and the inherited character was not fixed.

In this experiment, two sweet basil F_1 cultivars, 'Campione', a Genovese type with tall stem, shallowed cupped, egg-shaped leaves, and 'TSGI-156', an Italian large-leaf type with short stem, pointed serration, wrinkled wide leaves, were used to investigate their response to blue light.

MATERIALS AND METHODS

Sweet basil 'Campione' (Kobayashi Seed Co., Ltd., Japan) and 'TSGI-156' (Tokita Seed Co., Ltd., Japan) were sown in 6 cm diameter plastic pots. Seedlings were grown in an incubator (LI-200, Nippon Medical & Chemical Instruments Co., Ltd., Japan) with white fluorescence lamps, photosynthetic photon flux density (PPFD) of 120 $\mu mol \cdot m^{-2} \cdot s^{-1}$ at 16 hours light/8 hours darkness, and day temperature 25/night 20℃ until 4 true leaves developed. Light quality treatment was performed in a temperature-controlled room at 24±2°C. The monochromatic blue LED light (blue LED had peak wavelengths of 470 nm) and a mixed white LED light (blue: 470 nm, green: 530 nm, red: 630 nm, 1:1:1 mix ratio) put on 16-hr photoperiod. Each of treatments was screened with black cloth to preclude extraneous lights. The PPFD of each LED was adjusted to 120 $\mu mol \cdot m^{-2} \cdot s^{-1}$ at the top of plants. Eight plants were placed in each light quality treatment area for 14 days. Plant height and internode length were measured every 7 days, and the measurement sites were shown in **Figure 1**.

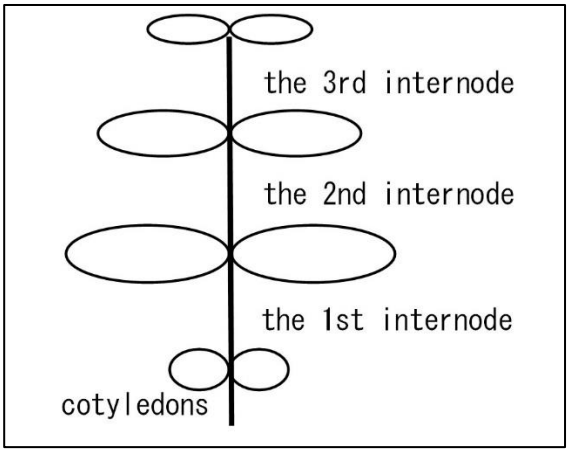

Figure 1. An explanatory diagram of the internodal positions targeted of sweet basil for investigation.

At the end of treatment, the third internode was collected and immediately fixed with formaldehyde-alcohol-acetic acid (FAA) (70% ethanol: formaldehyde: acetic acid, 90:5:5) solution and subsequently dehydrated with ethanol series solutions. All treated samples were embedded

in paraffin, and sections for microscopic observation were stained with 0.05% toluidine blue solution. Slides were observed using a digital microscope (VHX-1000, Keyence Corporation, Japan), The size of cortex cells was measured using the ImageJ software program.

RESULTS AND DISCUSSION

Plant height and internode length above the second node were higher and longer under the blue LED for both cultivars (**Fig. 2**). In Figure 2, each internodal length is shown in a different filled pattern, and the plant height is shown by stacking these internodal lengths. It should be noted that measurement was possible up to the 5th internode.

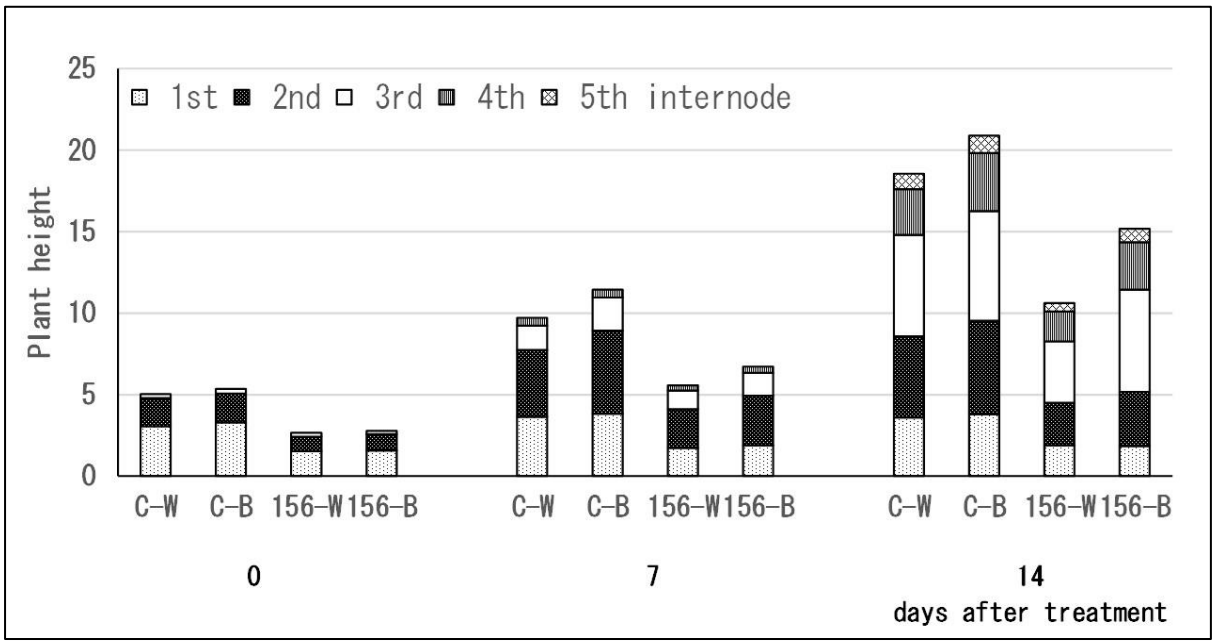

Figure 2. Plant height and individual internode length of sweet basil under white or blue light （n=8） C: ‘Campione’, 156: ‘TSGI-156’, -W: white LED, -B: blue LED.

The internode lengths at the second to fifth under the blue LED was 15% longer in 'Campione' and 32% longer in 'TSGI-156' than those under the white LED. The elongation rate was particularly high above the third internode of 'TSGI-156' under the blue LED. This may be due to the influence of light quality from the formation of the leaf primordium. The size of the cortex cells was not significantly different in 'Campione', although the short axis length of cells under the blue LED was about 4 μm longer than that under white LED. In 'TSGI-156', the long axis length of cells under the blue LED was about 60% longer than that under the white LED, a significant difference at the 1% level (**Table 1, Fig. 3**).

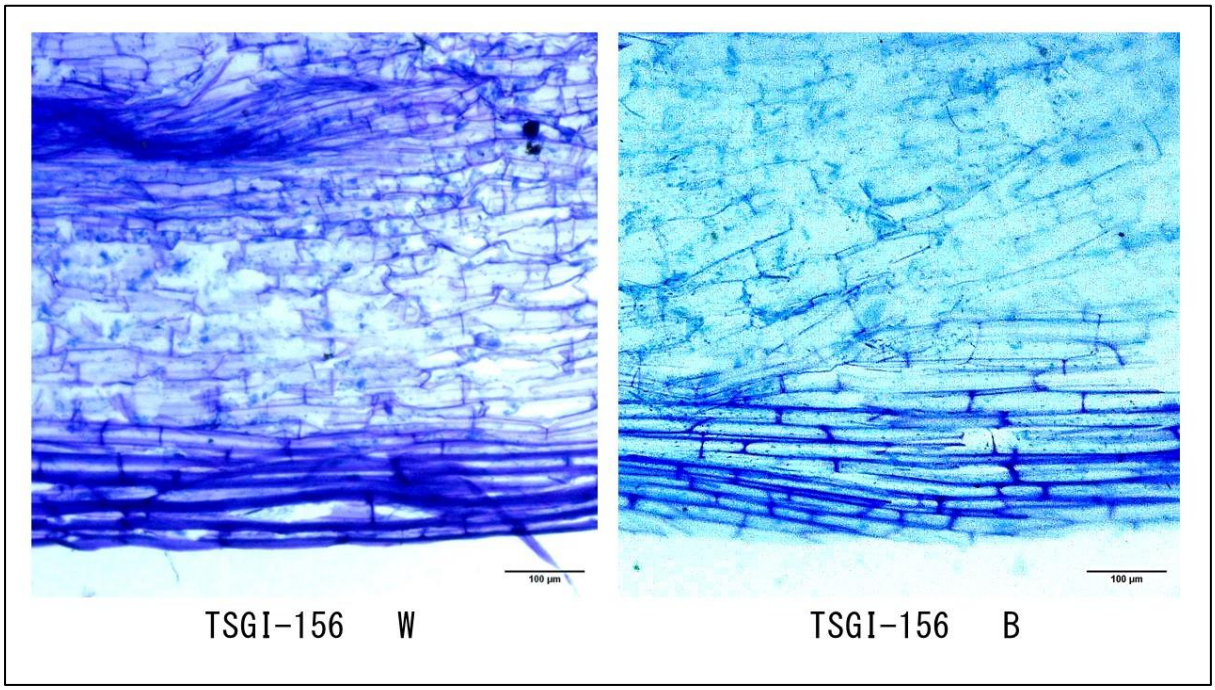

Figure 3. Longitudinal section of tissue the third internode of sweet basil under white or blue light (The lower side is the epidermis.

Table 1. Effect of light quality on the cell size of cortex of the third internode (μm) in sweet basil.

Cultivar name	Light quality of irradiation light	Cortex cell length (μm)	
		Long axis	Short axis
Campione	White	157.6 ± 31.3	29.9 ± 5.0
	Blue	157.3 ± 32.8	34.0 ± 9.3
TSGI-156	White	137.3 ± 47.0	28.6 ± 6.6
	Blue	218.6 ± 47.2	28.7 ± 6.1

n=30. average±standard deviation.

Blue light has been reported to have an inhibitory effect on plant stem elongation (Laskowski and Briggs, 1989; Shimizu et al., 2006). In this experiment, however, blue light promoted internodal elongation of sweet basil, the same result as previously reported by Amaki et al. (2012). In 'TSGI-156', the cortex cells were significantly

longer in the stem axial direction, which increased internode length and plant height. On the other hand, in 'Campione', which has a larger plant height than 'TSGI-156', showed less elongation effect by blue light. In sweet basil, the higher percentage of blue light irradiated resulted in increased plant height and stem thickening, as well as reduced dry matter weight and leaf area (Larsen et al., 2020). Under 100% (monochromatic) blue light, a reduction in biomass and leaf dry mass unit area and phytochrome activity has been reported in arugula, mustard and petunia (Johnson et al., 2020; Kong et al., 2018). These responses were like shade-avoidance responses induced by increased red light percentage and less light (Franklin and Whitelam, 2005; Ballaré and Pierik, 2017).

Sweet basil has greater transpiration than other plants (Patiño et al., 2018), and blue light promotes transpiration through stomata opening (Assmann and Shimazaki, 1999). The 'TSGI-156' used in this experiment has larger leaves than 'Campione'. We think that the attempt to make the leaves smaller to reduce transpiration by opening the stomata under blue light resulted in increased distribution of photosynthetic to the stem and internode than in 'Campione'. To determine the effects of blue light on sweet basil morphogenesis, measurements of leaf area, dry matter weight, and phytohormone content in addition to respiration and transpiration are needed.

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