COMPARISON OF THE EFFECTS OF LED LIGHT QUALITY COMBINATION ON GROWTH IN A CONTROLLED ENVIRONMENT HORTICULTURE IN GREEN CHILI (CAPSICUM FRUTESCENS)

[1]RAKIBUL HASAN ROKI, [2]TANMOY ACHARYA, [3]NAFISA RAIHANA

[1]Executive,Laxfo Electronics Limited,Taiyabpur,Zirabo,Ashulia,Dhaka-1341
[2]Assistant Manager, Laxfo Electronics Limited,Taiyabpur,Zirabo,Ashulia,Dhaka-1341
[3]Executive,Laxfo Electronics Limited,Taiyabpur,Zirabo,Ashulia,Dhaka-1341
E-mail: [1]rakibul.hasan@laxfo.com,[2]tanmoy.acharya@laxfo.com,[3]nafisa.raihana@tafuri-group.com

Abstract: This study explores how green chili (Capsicum frutescens) plant growth is affected by blue and red light spectra, focused on important factors including hypocotyl height, total leaf area, stem diameter and stem strength under controlled environment. According to our research, there considerably improves hypocotyl height and total leaf area, which suggests improved leaf expansion and stem elongation under red light. On the other hand blue light promotes stronger stems in green chili plants. These findings suggested that the most successful method for maximizing green chili growth may use both the blue and red light spectra.

Keywords - Green Chili, LED Light, Growth, Total Leaf Area, Photosynthesis

I. INTRODUCTION

Horticulture lighting is the application of light that is artificial, such as LEDs to stimulate growth of plants in controlled conditions. These systems provide specific light spectrums, intensities needed by different plants for healthy growth and adequate yields. Light quality, intensity, and photoperiod are the three most fundamental factors influencing plant growth. These three factors have an impact on a plant's morphology [1], growth rate[2], and primary and secondary metabolite content[3].

So light is not only an essential source of energy for photosynthesis, but it is also an important factor affecting plant growth and development[4]. Blue light and red light are well recognized to be more effective than other wavelengths of light in the photosynthetic process[5].Red light having more quantum efficiency, but blue light limits plant photosynthetic rate by affecting its photosynthetic system [6][7].

Several studies have found that blue light influences plant growth and morphology, such as the prevention of large stem growth [8]. Red light improves the elongation of tomato petioles and stems, unwinding the plant structure [9]. In short light is a major factor in how plant morphology is influenced.

Green chili is one of the most common crops. But research on horticulture lighting for green chili has been less than other crops.This study evaluated the impact of green chili development and growth to various light treatments. It also showed the effects of hypocotyl height, stem diameter and total leaf area under different lighting condition. These results may provide suggestions to crop growers who are attempting to grow green chili on horticulture system.

II. MATERIALS AND METHODS

a. Plants Material and Growing Conditions

The experiment took place in Zirabo, Ashulia, Dhaka (23°55'10.5"N, 90°18'44.6"E). There are two boxes and the volume of each box is 60cm*20cm* 60cm. The experiment was conducted in the presence of blue and red lights, with each box containing four seedlings . The average temperature and relative humidity in each box were 25°C and 50%, respectively.

b. Experimental Plan and led lighting system

Seedlings of the Green Chili (Capsicum frutescens) were grown from seeds in a tub in the presence of blue light and red light. Seedlings were transplanted to 8 different tubs after germination. Four tubs were in blue light, and the other tubs were in red light. Tubs in a box were rotated out at regular intervals. These tubs received 14 hours of continuous light each day. Every few days, the seedlings' height, diameter, and total leaf area were measured. Although previous research had suggested the impact of various wave lengths on plant development, the spectrum impact of light on plant development was first documented roughly a century ago[10]. Despite this early research, the processes governing these responses are still not fully understood.

Furthermore, the interaction and nature of interdependence between some types of photoreceptors are not fully known[11]. The chemical reactions of photosynthetic pigments, including as chlorophylls and carotenoids, are primarily connected to light capture and energy transfer during photosynthesis. Chlorophylls are most sensitive in the blue and red areas, which are around 350-480 nm and 600-700 nm, respectively. Carotenoids, such as xanthophylls and carotenes, absorb primarily blue light and are also known as chlorophyll auxiliary

photoreceptorsFigure 1. That's why 450nm and 635nm were used. This are shown in Figure 2&Figure 3.

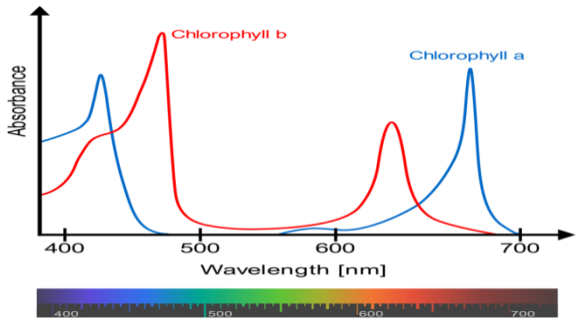

Figure 1:Chlorophyll a & chlorophyll b absorption spectra in the visible light range [12]

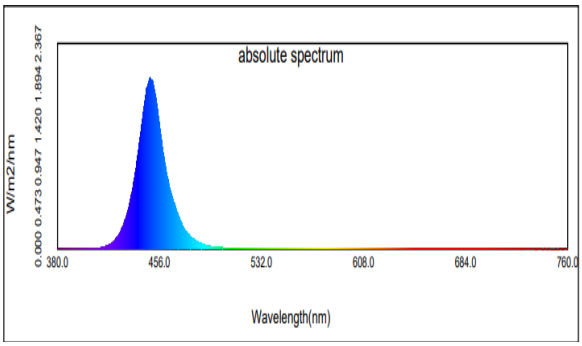

Figure 2:Spectrum of Blue Light

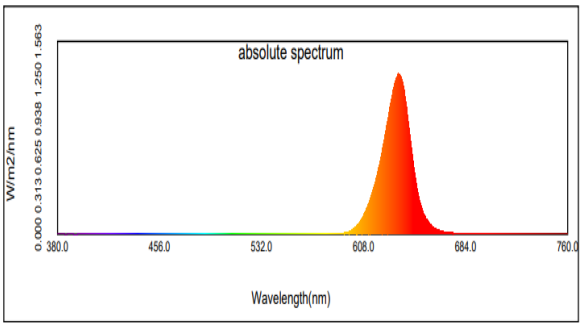

Figure 3:Spectrum of Red Light

c. Data Measurement

Every four days, all of the plants in each pot were measured. No measurements were done earlier as the germinated plants were too little for the single pot. The measured parameters were the average height of plants for single box, average diameter of hypocotyl for a single box and leaves area. A digital caliper (Tolsen 35053) was used to calculate the height, and the experiment's value reference was the arithmetic average of each plant in the same box. Using ImageJ software, leaves area was calculated by performing photo analysis on pot pictures obtained from a vertical view point. To determine the Leaf Area Index (LAI), the resulting leaf area was used . The ratio of a plant's leaf area to its soil area is known as the leaf area index [13].

Figure 4:Some example of a photograph captured of each pot

III. RESULT & DISCUSSION

a. Plant Vegetable Growth

The analysis of data presented Table 1&Table 2indicates the growth of green chili under different conditions. In the results obtained in the present, it can be noted that the different types of light had a significant effect on the diameter of stem, length of the hypocotyl and the total leaf area.

Days	Hypocotyl Length(mm)	Stem Diameter(mm)	Total Leaf Area (cm^2)
7	30.16	0.8025	0.9842
11	31.43	0.87	1.0887
15	31.785	0.9025	1.6335
19	33.245	0.93	2.7402
23	34.52	0.965	3.2187
27	35.285	0.975	3.437
31	35.8075	1.0175	4.232
35	36.6875	1.0875	5.087
39	36.6925	1.1775	5.6767
43	37.7325	1.2425	6.2985
47	38.195	1.3625	6.382

Table 1: Morphological parameters of Green chili under blue light.

Days	Hypocotyl Length(mm)	Stem Diameter(mm)	Total Leaf Area (cm^2)
7	30.16	0.74	1.10125
11	32.445	0.795	1.11175
15	33.04	0.845	1.7239
19	36.05	0.875	3.30925
23	37.61	0.98	4.70525
27	38.285	1.0575	7.4375
31	40.0175	1.2	14.0427
35	40.9375	1.275	14.5962
39	41.3375	1.4475	19.442

43	41.55	1.505	20.2535
47	41.955	1.69	31.0567

Table 2: Morphological parameters of Green chili under red light

b. Discussion

We are all know that light is an important environmental element for plant growth, development, and photosynthesis. The intensity&the quantity of light can act like aimportant component during plant growth and have a direct impact on plant morphology. Some research has shown that photoreceptors in seedlings can respond by detecting the surrounding light environment [14][15]. The separate effects of blue and red light play a role in regulating photosynthesis and plant growth [16]. In our study, there were significant changes in the morphology and growth status of green chili under different LED lighting conditions. We observed that compared with Blue light, the development of green chili was accelerated by red light treatment. After 47 days, the average height of hypocotyl, diameter, total leaf area of green chili has increased by 8.035 mm,0.6125 mm and 5.88825 cm^2 respectively under the blue light. On the other hand the average height of hypocotyl, diameter, total leaf area of green chili has increased by 11.6793 mm, 0.925 mm, 29.95425 cm^2 respectively under the red light We also observed that the plant stems are stronger in blue light than in red light.The stems of green chili under blue light is close to the stem under sun light. But there is a difference under red light.

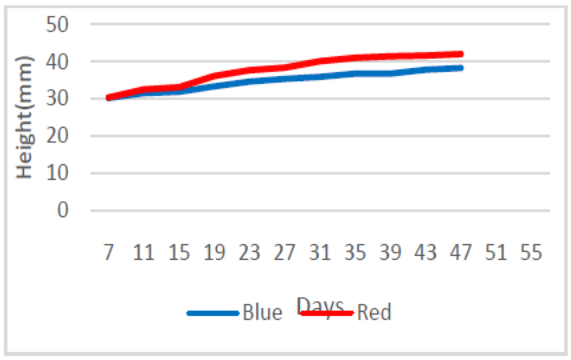

Figure 5:Comparison of the height of hypocotyls

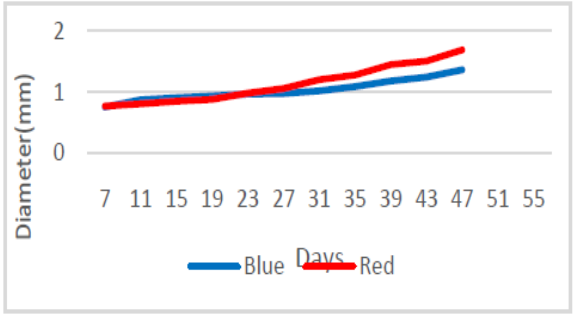

Figure 6:Comparison of the diameter of stem

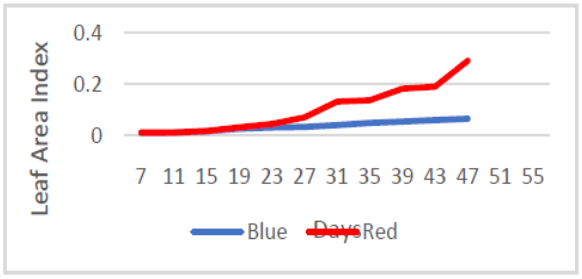

Figure 6:Comparison of the leaf area index

IV. CONCLUSION

The growth and development of green chili can be significantly impacted by the quality of the light. Here, We observed that red light promotes more leaf expansion than blue light and could increase a plant's ability for photosynthesis and red light is essential for the early growth stages of the stem's elongation. On the other hand blue light has a important effect on stem strength which is necessary for the plant's structuralsupport. Our opinion is that the growth and production of a plant could be improved by applying both lights.

ACKNOWLEDGEMENT

The authors are extremely thankful to Laxfo Electronics Limited for funding this research.

REFERENCES

[1] L. E. Särkkä, K. Jokinen, C. O. Ottosen, and T. Kaukoranta, “Effects of HPS and LED lighting on cucumber leaf photosynthesis, light quality penetration and temperature in the canopy, plant morphology and yield,” Agricultural and Food Science, vol. 26, no. 2, pp. 101–109, 2017, doi: 10.23986/afsci.60293.

[2] X. Yang, H. Xu, L. Shao, T. Li, Y. Wang, and R. Wang, “Response of photosynthetic capacity of tomato leaves to different LED light wavelength,” Environ Exp Bot, vol. 150, pp. 161–171, Jun. 2018, doi: 10.1016/j.envexpbot.2018.03.013.

[3] H. Dou, G. Niu, M. Gu, and J. G. Masabni, “Effects of light quality on growth and phytonutrient accumulation of herbs under controlled environments,” Horticulturae, vol. 3, no. 2. MDPI Multidisciplinary Digital Publishing Institute, Jun. 01, 2017. doi: 10.3390/horticulturae3020036.

[4] K. Meiramkulovaet al., “The efficiency of led irradiation for cultivating high-quality tomato seedlings,” Sustainability (Switzerland), vol. 13, no. 16, Aug. 2021, doi: 10.3390/su13169426.

[5] K. J. McCREE, “THE ACTION SPECTRUM, ABSORPTANCE AND QUANTUM YIELD,” Agricultural Meteorology, pp. 191–216, 1971.

[6] M. Legris, Y. Ç. Ince, and C. Fankhauser, “Molecular mechanisms underlying phytochrome-controlled morphogenesis in plants,” Nature Communications, vol. 10, no. 1. Nature Research, Dec. 01, 2019. doi: 10.1038/s41467-019-13045-0.

[7] B. J. R. Snget al., “Combination of red and blue light induces anthocyanin and other secondary metabolite biosynthesis pathways in an age-dependent manner in Batavia lettuce,” Plant Science, vol. 310, p. 110977, Sep. 2021, doi: 10.1016/J.PLANTSCI.2021.110977.

[8] E. S. Runkle and R. D. Heins, “Specific functions of red, far red, and blue light in flowering and stem extension of long-day plants,” Journal of the American Society for Horticultural

Science, vol. 126, no. 3, pp. 275–282, 2001, doi: 10.21273/jashs.126.3.275.

[9] J. Wang, W. Lu, Y. Tong, and Q. Yang, "Leaf morphology, photosynthetic performance, chlorophyll fluorescence, stomatal development of lettuce (Lactuca sativa L.) exposed to different ratios of red light to blue light," Front Plant Sci, vol. 7, no. MAR2016, Mar. 2016, doi: 10.3389/fpls.2016.00250.

[10] A. R. Cashmore, J. A. Jarillo, Y. J. Wu, and D. Liu, "Cryptochromes: Blue light receptors for plants and animals," Science, vol. 284, no. 5415. pp. 760–765, Apr. 30, 1999. doi: 10.1126/science.284.5415.760.

[11] E. P. Spalding and & K. M. Folta, "Illuminating topics in plant photobiology," 2005.

[12] Y. T. A. R. and S. B. N. Bruce F. Milne, "Chlorophyll _ Max Planck Institute for the Structure and Dynamics of Matter," AngewandteChemie International Edition, pp. 2170–2173, Mar. 26, 2015.

[13] N. J. J Bré da, "Global products of vegetation leaf area and fraction absorbed PAR from year one of MODIS data," 2004. [Online]. Available: http://daac.ornl.gov

[14] F. Yang et al., "Yield response to different planting geometries in maize-soybean relay strip intercropping systems," Agron J, vol. 107, no. 1, pp. 296–304, Jan. 2015, doi: 10.2134/agronj14.0263.

[15] Z. C. Zuo et al., "A study of the blue-light-dependent phosphorylation, degradation, and photobody formation of Arabidopsis CRY2," Mol Plant, vol. 5, no. 3, pp. 726–733, 2012, doi: 10.1093/mp/sss007.

[16] D. Jin et al., "Effect of Red and Blue Light on Cucumber Seedlings Grown in a Plant Factory," Horticulturae, vol. 9, no. 2, Feb. 2023, doi: 10.3390/horticulturae9020124.

★★★