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Artificial Lighting – Impact of LED Light on Various Attribute of Plant

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SUMMARY

Seeing towards the pressure arising from rising population and erratic climatic variation, more attention is required towards the development of technology driven horticulture. People need to adopt most efficient way of farming i.e., indoor farming. Light Emitting Diode is a key most important assets of the indoor farm. Present research is done on impact of various colour LED lighting on the plant growth (Vegetative and Flowering growth), photosynthesis, transpiration, yield, harvesting, ripening process and IPM.

INTRODUCTION

Precision farming can be defined as "application of modern technologies to provide, analyze and process multisource high spatial and temporal data for making decision in the crop production technology and increase resource use efficiency." Concept of precision farming in first came in light in early 1980 in united states. [Anon. (2021_a)] "Indoor farming is a technique to grow plant at commercial level or for the kitchen purpose in a fully enclosed or opaque room by using artificial light sources and maintaining the temperature, relative humidity, light period." [Anon.(2021_b)] Concept of indoor vertical farm arise in 1999 in the mind of Dr. Dickson Despommier. [Anon. (2021_b)] Light is key factor of the environment that affect the plant growth. Light is important for the photosynthesis and bio-mass accumulation. Light affecting the photoperiodism which turn plant vegetative growth into the flowering or vice-versa. LED defined as "semiconductor light source that emits light when current flow through it." [Anon. (2021_c)] Most of the urban peoples are moving toward the concept of indoor farming to satisfy the food requirement. At this point natural light for photosynthesis is main concern, during this time people bring out the substitute of the natural sunlight as an artificial lighting. It is an artificial source of light required for plant growth and development. By this we mimic the wavelength spectrum of the sunlight in various color. [Anon. (2021_d)] Various types of grow light are currently available in the market. [Anon. (2021_c)]. **e.g.,**1. High Intensity Discharge Light (HID), 2. Metal Halide (MH), 3. Ceramic Metal Halide (CMH), 4. High Pressure Sodium (HPS), 5. LED, 6. Fluorescent light and 7. Compact Fluorescent Lamp (CFL)

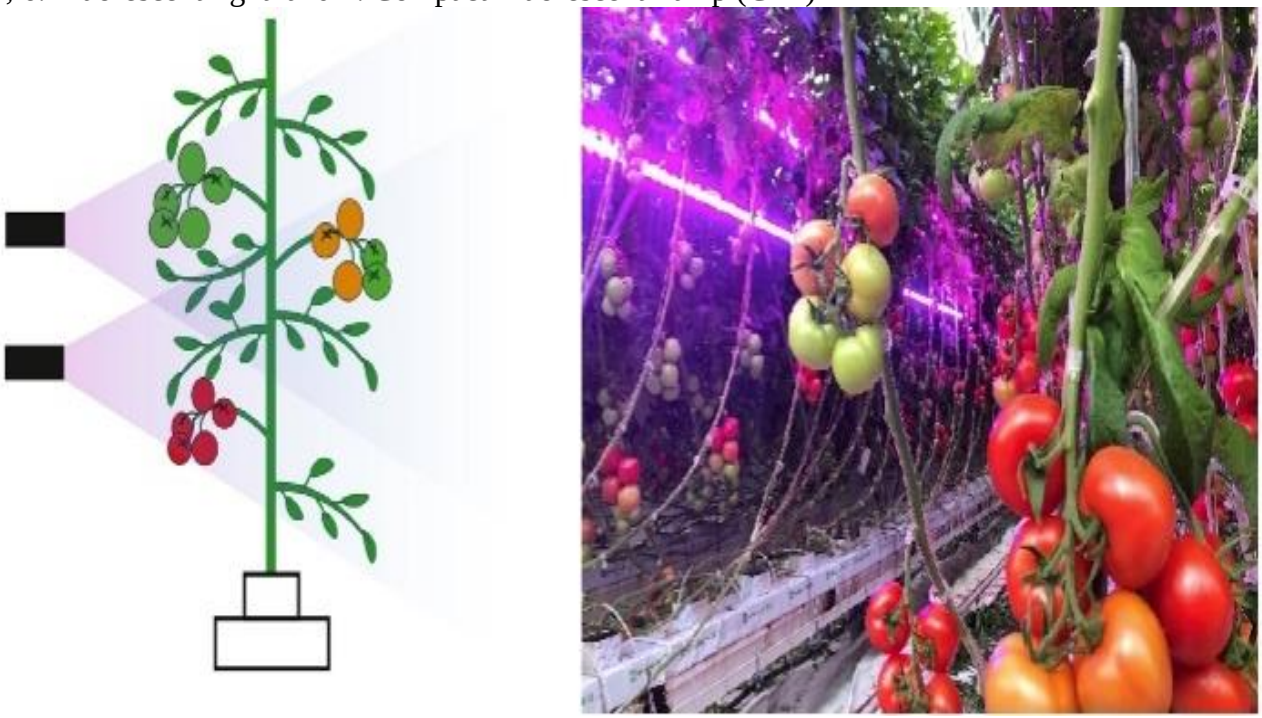

Fig. Supplemental LED inter-lighting in tomato plant. **Source:** Paucek, *et. al*., (2020)

Among all this, LED is mostly used as artificial light in the indoor farming. So, let's discus some impact of it on plant.

Which color of LED light is used as a grow light

Red, Far- red, Blue, Purple, Pink, Yellow, Green, White, Orange LED light is used in agriculture. [Anon. (2021_e)] Among this absorption of red LED light is easily understand because these wavelengths perfectly fit with the absorption peak of chlorophylls (Schoefs B., 2002).

Impact of LED light on plant growth

Illumination of more than 50% of the green LED light cause a reduction of plant growth, whereas treatment containing 24% green LED light exposure enhanced the growth of some plant species (Kim HH *et al*., 2006).

Impact of LED light on plant photosynthesis

Among different sources of light LED light is most convenient option for indoor farm because of maximum PAR (80 – 100%) (Darko Eva *et al*., 2014) which provide most suitable wavelength to the plant for photosynthesis. White color LED light is mostly used for normal photosynthesis because it has all spectrum of light. Blue + Red light combination shows higher photosynthetic activities than under either monochromatic light (Sabzalian M. R. et al., 2014). LED light structure is generally fixed just above (nearby) the plant leaves to get more PPFD (Photosynthetic Photon flux Density) (Yeh N and Chung JP., 2009.) Stomatal opening is mainly controlled by blue colour photoreceptor which provide more CO_2 for more photosynthesis (Kim HH *et al*., 2006).

Impact of LED light on plant transpiration

LED is most convenient option among all grow light for making the environment around the plants cool and humid in indoor farm, that helps to minimizes the transpiration and optimize the Water Use Efficiency (WUE). Passive thermal management system of LED light is mostly used because this type of LED is more energy efficient and durable. [Anon. (2021_f)]

Impact of LED light on vegetative growth of plant

Plants use blue spectrum of visible light, for the vegetative growth of plant. Wavelength of this spectrum is around 430-460 nm. [Anon. (2021_g)] That's why we see bluish appearance of indoor farm during vegetative growth of plant. This light exposure is given to the plant during early and mid-stage of growth. More exposure of blue light is increasing the shoot dry matter. For achieving tall growth in stem plant to be exposed to yellow, far-red, orange, green color LED light, if you want a compact/short stem growth then you have to be exposed plant to blue, UV light LED. [Anon. (2021_h)]

Impact of LED light on flowering growth of plant

Plants use the red spectrum. This spectrum of light which helps in promoting the flowering growth. Wavelength of this spectrum is 630-660 nm. [Anon. (2021_g)] Photoperiodism is a most important phenomenon which induce the flowering in plant. On the basis of photoperiodism the plants are classified in 3 various groups: 1. Long Day Plant (LDP), 2. Short Day Plant (SDP), 3. Day Neutral Plant (DNP) [Anon. (2021_h)]. For the induction of flowering in the LDP plants should be exposed to more red LED light than far-red LED light. In contrast of this if you want to promote flowering in SDP then you have to expose plant to more far-red LED light than red LED light. [Anon. (2021_h)]. The length of night is more important than length of the day to induce flowering in plant. In the old-time foreign greenhouse grower lit up the red LED light after sunset to expand the day length, which is more costly and non-sustainable way, but after this discovery in context of this some foreign greenhouse holder use one unique method to induce flowering in LDP they only give flash of the red LED light at the mid of the night. It has been proved the milestone for this farmer because it reduces their cost of cultivation, Energy efficient way and also the sustainable way, which is the prime most goal of today's researcher.

Impact of LED light on yield, harvesting and ripening of fruits

In forcing culture of tomato, 14% increase in yield and also productivity reported in the supplemental LED interlighting (Ivan paucek *et al*., 2020). White and red colour supplementary interlighting is proven more effective than blue one (Lu, N. *et al*., 2012). Supplemental LED inter-lighting during spring and summer on vegetable hydroponic farm in Bologna, Italy (44◦34'49" N, 11◦31'54" E), Hydroponic grower observed that this inter-lighting(white, red, blue LED light)increase the yield of the tomato and total soluble solids content of tomato (emitting 200 µmol m^{-2} s^{-1} at 10 cm from 16 h d^{-1}) (Lu, N. *et al*., 2012) but no any impact on sugar content (RB = 95:5, daily light integrals of 25 mol m^{-2} d^{-1}) (M.P. Dzakovich et al., 2011) and fruit color at the time of harvesting, but it also accelerates the rate of ripening of the tomato fruit by 1 week and 2 weeks respectively in spring and summer (Gupta *et al*., 2014)

Impact of LED light on IPM of plant

The possibilities of manipulating pests and beneficial species can be increased by development artificial lighting technologies and greenhouse cladding materials. Plant functions and physical and chemical quality depended on photoperiod, light intensity and wavelength distribution which can be reflected in the performance of herbivores. Direct effect of LED light on arthropods is more effective, like the inability of locating host plants by visually orienting pests in red and blue light. Other detrimental impact of LED light in spectra of UV-C and UV-B on arthropods and fungi, diapause prevention by species-specific wavelengths on photoperiods, polarized light and attraction to yellow-green wavelengths, reduced visibility of prey in specific spectra which reduces vector transmitted diseases. Also, resistance can be induced in plants to plant pathogenic fungi by red light. (Vänninen I. *et al*., 2012)

CONCLUSION

LED light impacts on different plant growth parameters in positive way and provide better quality illumination than the traditional light source with less than half amount of electric input. The range and colour also affect the performance of LED light on development of plant.

- Red light is generally absorbed by chlorophylls.
- 24 % green LED light enhance the growth of plant.
- Passive thermal managed LED light is more advisable to most of the indoor farmer.
- Blue LED light increase the shoot dry matter.
- Ratio of the red and far-red Led light impact the flowering growth.
- Yield in tomato plant can be increased by the use of inter-lighting, while harvesting time cam be reduced by using red and blue supplemental LED lighting along with it accelerate the rate of ripening.
- Red and blue LED lighting impact on translocation of arthropods. Red LED lighting induce resistance against fungi in plant.

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