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Effect of Light Colour in Protected Cultivation for Growth and Development of Vegetable

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Light is a critical external factor influencing plant growth and development, both under normal environmental conditions and in response to stress. The quality and spectra of light are particularly significant throughout the entire ontogenetic cycle of a plant, not just its presence. Naturally, the amount and quality of light vary daily and seasonally These variations affect not only photosynthesis but also light signaling pathways. These pathways are interconnected and play a role in plants' acclimatization to different environmental conditions, modulating growth and development processes by influencing physiological and biochemical mechanisms.

Effect of light

In addition to open-field cultivation, the impact of light is crucial for in vitro cultures, greenhouse cultivation, tunnel farming, and post-harvest processes. It's not just the presence of light that matters; the quality and spectra of light are pivotal throughout the plant's life cycle, influencing germination, photomorphogenesis, and floral induction. Moreover, the spectral composition of light significantly affects how plants respond to various stress factors, both abiotic and biotic.

In controlled environments, different lighting sources can be utilized to enhance climate control, and solar radiation can be influenced by climate screens and nets, affecting light transmittance based on the materials used. To reduce costs and improve yield and quality in plant factories, implementing an intelligent lighting control system, such as a cloud-based lighting management system, is seen as beneficial for future greenhouse use.

The use of light-emitting diodes (leds) in indoor farming systems, like vertical farms, is a modern technique to alter light spectral composition, thereby regulating plant growth and development and producing high-nutrient or nutraceutical crops. Leds offer advantages in horticulture, including control over spectral composition, high light levels with minimal heat output, and long-lasting performance without frequent replacement. This makes leds of significant interest for both scientific and practical applications.

Manipulating light quality through photo-selective netting or films can enhance both the yield and quality of horticultural produce, including their chemical composition. Given the negative impact of environmental changes on vegetable yield and quality, indoor farming under LED lighting is increasingly seen as a sustainable solution for controlled environment agriculture. This review aims to present recent findings on the effects of blue light from leds on plant physiological parameters during the growing season, resulting in improved yield and nutritional quality, including post-harvest preservation.

Blue Light Emitting Diodes (LEDs) Effects on Plant Physiology

The effects of light, particularly its spectral composition, are well documented in plant physiology, influencing processes from seed germination to seedling growth. Some seeds, like those of *Cleome gynandra*, exhibit light-induced dormancy, where light inhibits germination. However, blue light can counteract this dormancy, enhancing germination rates up to 35%, while red light can inhibit germination to about 8%. Additionally, blue light, combined with organic biostimulants, can increase protein and carbohydrate content in seeds and boost the activity of enzymes like alpha-amylase, superoxide dismutase, and catalase, thus promoting germination and seedling growth.

Role of Cryptochrome in Plant Development

Cryptochrome, a blue light receptor, plays a critical role in plants such as tomatoes, influencing seed mass, early seedling growth, hypocotyl elongation, and root development. For instance, cryptochrome impacts the elongation of the hypocotyl and root development in young plants. In contrast, studies on spruce have shown that green light stimulates germination and growth, while blue light inhibits hypocotyl elongation.

Photoreceptors and Light Signaling

Plants possess specific photoreceptors like phytochrome, cryptochrome, and phototropins, which detect different light wavelengths (red/far-red, blue/UV-A, and UVB, respectively). These receptors capture light information and activate signaling networks that regulate photomorphogenesis and various molecular and physiological processes throughout the plant's lifecycle. Blue light has been shown to affect plant morphology and growth, as well as the functioning of the photosynthetic apparatus, including chloroplast modifications and the efficiency of photosystems in the thylakoid membranes.

Blue Light in Early Photomorphogenesis and Chlorophyll Accumulation

In Arabidopsis thaliana, blue light plays a significant role in the early stages of photomorphogenesis and cytokinin-dependent greening. Inactivation of blue light signaling components (CRY1, CRY2, and HY) delays chlorophyll accumulation, whereas cytokinin application accelerates de-etiolation and increases chlorophyll fluorescence.

Morphological Effects of Light Quality

Light quality can influence internode or petiole elongation and leaf expansion, impacting light absorption and plant productivity via photosynthesis.

Leaf deformations caused by light quality can reduce biomass yield and ornamental value in decorative plants.

Cryptochrome's Impact on Adult Plants

In adult tomatoes, cryptochrome affects flowering time and plant architecture. The absence of functional cryptochromes (CRY1a and CRY2) accelerates flowering by repressing the SELF PRUNING (SP)5G gene, a known inhibitor of flowering. This makes cryptochrome a potential target for manipulating physiological processes to optimize plant development and fruit composition.

Blue Light Alleviation of Red-Light Syndrome

Continuous exposure to red light can lead to "red light syndrome" in cucumber plants, characterized by reduced photosynthetic capacity, unresponsive stomatal conductance, and low chlorophyll fluorescence yield. Blue light can mitigate these effects by altering chloroplast ultrastructure and improving nutrient accumulation. Using a combination of red and blue leds can balance these effects, promoting healthier plant growth.

Conclusion

This review highlights the significant effects of blue light on plant physiology, from germination to adult plant development. By understanding and manipulating light quality, particularly with leds, it's possible to enhance plant growth, yield, and quality, making it a vital tool in modern agriculture.

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