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HARVESTING WITH LEDS: THE NEW FACE OF INDOOR FARMING

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Introduction

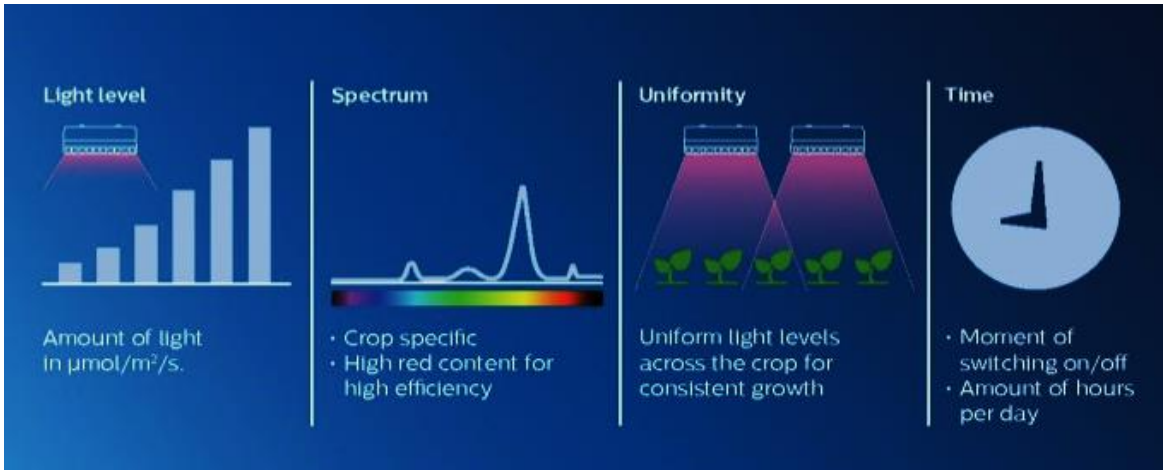
The global population is projected to reach 9.7 billion by 2050, with 55.7 per cent residing in urban areas, creating a growing demand for food in cities. Simultaneously, agricultural land is shrinking due to urbanization and climate change, and conventional farming struggles to meet future food needs due to water scarcity, reduced land availability and waning interest from younger generations. Controlled Environment Agriculture (CEA), or indoor farming, offers a sustainable solution by enabling crop cultivation in controlled conditions, enhancing productivity per unit area and ensuring profitability. Light plays a critical role in indoor farming, as intensity, quality and photoperiod significantly impact plant growth. Traditional lighting systems such as fluorescent and high-pressure sodium lamps are energy-intensive and inefficient.

In contrast, Light Emitting Diodes (LEDs) offer higher efficiency (80–150 lm/W) and consume less power. LED farming uses LED lights to provide specific wavelengths tailored to plant photoreceptors, optimizing photosynthesis, growth and flowering. LEDs produce minimal heat, allowing inter-canopy lighting to improve light penetration. This system enables year-round production of nutritious crops, particularly leafy greens and vegetables, irrespective of climatic conditions. LED farming represents a sustainable, innovative solution to global food security, maximizing productivity while addressing environmental and resource challenges.

Science of LED Farming

Plants require light, air, water and nutrients as essential growth factors. The regulation of such factors at optimal levels is crucial for achieving a plant's maximum growth potential. LED farming presents an innovative solution by enabling precise control over these elements in a controlled environment. Light is a critical factor, as its intensity, spectrum and photoperiod directly influence photosynthesis and plant development. LEDs are highly adaptable, offering specific wavelengths that align with plant photoreceptors to maximize growth efficiency, flowering and nutrient accumulation. The ability to customize light intensity and spectrum ensures that plants receive optimal energy for each growth stage, from germination to harvest. Beyond light, LED farming integrates advanced systems to regulate water and nutrient delivery through precision irrigation and hydroponic techniques.

Further, it is combined with carefully controlled temperature, humidity and carbon dioxide levels, which creates a perfectly optimized environment for plant growth. It minimizes resource waste, reduce the risk of pests and diseases and support year-round cultivation, independent of weather or soil conditions. LED farming enhances productivity while ensuring the production of healthy, nutrient-rich greens and vegetables. It represents a cutting-edge approach to sustainable agriculture, addressing the global challenges of food security and environmental conservation.



(https://www.lighting.philips.com/)

Techniques to intensify LED lighting efficiency in crop cultivation

The light use efficiency of LED lighting can be significantly enhanced through various strategies such as intercanopy lighting, targeted lighting and precise control of Photosynthetic Photon Flux (PPF). The approaches focus on maximizing the capture of photons by plants, thereby improving energy efficiency and plant productivity.

LED farming is transforming agriculture by enhancing crop productivity and quality through precise light spectrum control. Unlike traditional lighting, LEDs offer energy efficiency, compact size, durability, and customizable spectra. While the initial investment is high, long-term benefits include increased yields, energy savings and improved crop quality. LEDs enhance photosynthesis, biomass, chlorophyll and secondary metabolites while extending shelf life and protecting against pathogens. Advances in smart LED systems with sensors and wireless connectivity enable real-time plant monitoring, optimizing growth. As LED technology evolves, improvements in spectrum customization, efficiency, and cost-effectiveness will drive its role in addressing global food security challenges.

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