THE BENEFITS OF UNDER-CANOPY LIGHTING FOR INDOOR CANNABIS PRODUCTION

When cultivating cannabis in controlled environments, it is common to use strains that exceed three feet in height. This vertical growth, when coupled with an industry preference for high planting densities, inevitably leads to the formation of crop canopies that are exceedingly thick and dense. Even with methodical use of labor-intensive canopy management techniques, such as extensive pruning and defoliation, the inherent size of these canopies often leads to suboptimal light distribution. The result is inadequate penetration of photosynthetic active radiation (PAR) throughout the entire canopy, and especially to the lower and interior portions, which will negatively impact the development of flowers.

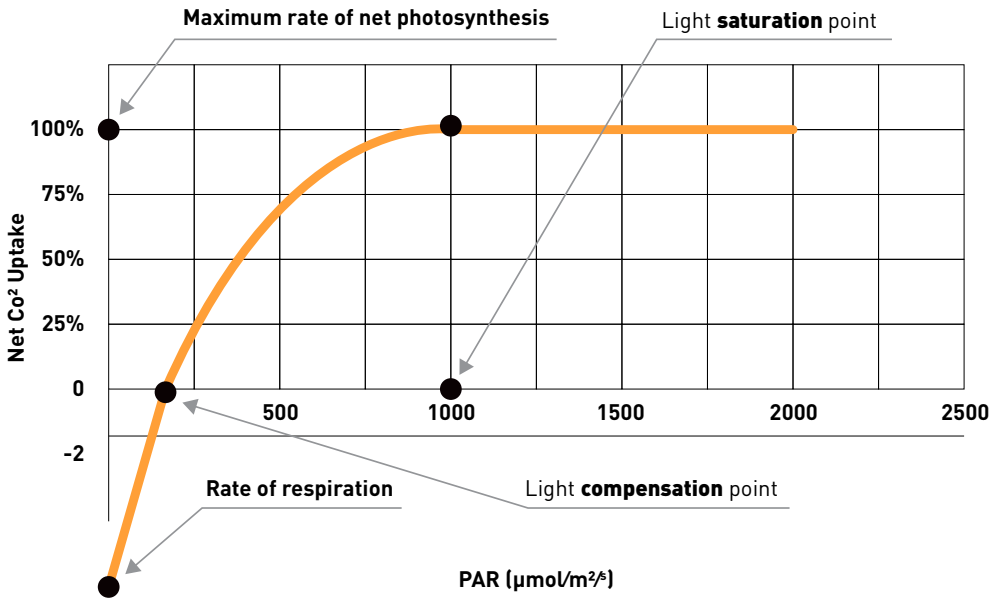
The detrimental effects are twofold: a quantifiable reduction in overall flower yield and a noticeable decline in the intrinsic quality of the harvested product, primarily due to insufficient light exposure to the developing bud sites. This phenomenon underscores a critical need for innovative cultivation strategies that can mitigate the negative impacts of dense canopies while maintaining or enhancing productivity. One possible solution includes integrating under-canopy lighting fixtures into the growth environment in order to create a more uniform light environment throughout the plant's life cycle.

Dense canopy limits light to lower buds, reducing yield and quality — showing the need for under-canopy lighting.

HOW UNDER-CANOPY LIGHTING WORKS

Plants are photosynthetic, which means they use light to produce the chemical energy, in the form of sugars, to fuel their metabolism and growth. Cannabis cultivators typically target a photosynthetic photon flux density (PPFD) intensity of 1,000-1,500 µmol m-2 s-1 at the top of the canopy using horticultural toplight fixtures. This irradiance level approaches the photosynthetic saturation point, thereby providing a light environment that supports maximum biomass accumulation. However, a significant proportion of incident photons are intercepted by the upper canopy. Since the rate of photosynthesis is highly correlated to light intensity, lower light level in the bottom of the canopy significantly restricts sugar production making it impossible to match the rapid growth observed in the upper canopy.

To put this in perspective from the plant's point of view it is helpful to refer to a theoretical photosynthetic light response curve (see figure below). Leaves receiving light levels at the light saturation point will ensure a maximum rate of photosynthesis, and thus, a maximum rate of growth. But at lower light levels, the rate of photosynthesis drops in a nearly linear fashion (i.e. every 1% decrease in light intensity equals a 1% reduction in photosynthesis). For example, an intensity of 1,000 µmol m-2 s-1 PPFD
(photosynthetic photon flux density) at the top-most growing point and 300 µmol m-2 s-1 PPFD at the base of the stem means that only 30% of the light needed for optimal growth is reaching the bottom of the canopy. In severe cases, if light intensity drops below approximately 100 µmol m-2 s-1 PPFD, leaves cease being net producers of sugars. The precise PPFD at which a leaf produces exactly enough energy to meet the minimum metabolic requirement to remain alive is known as the light compensation point. Below that level, leaves will be 'stealing' energy that could otherwise be allocated to developing flowers or for making cannabinoids and terpenes.

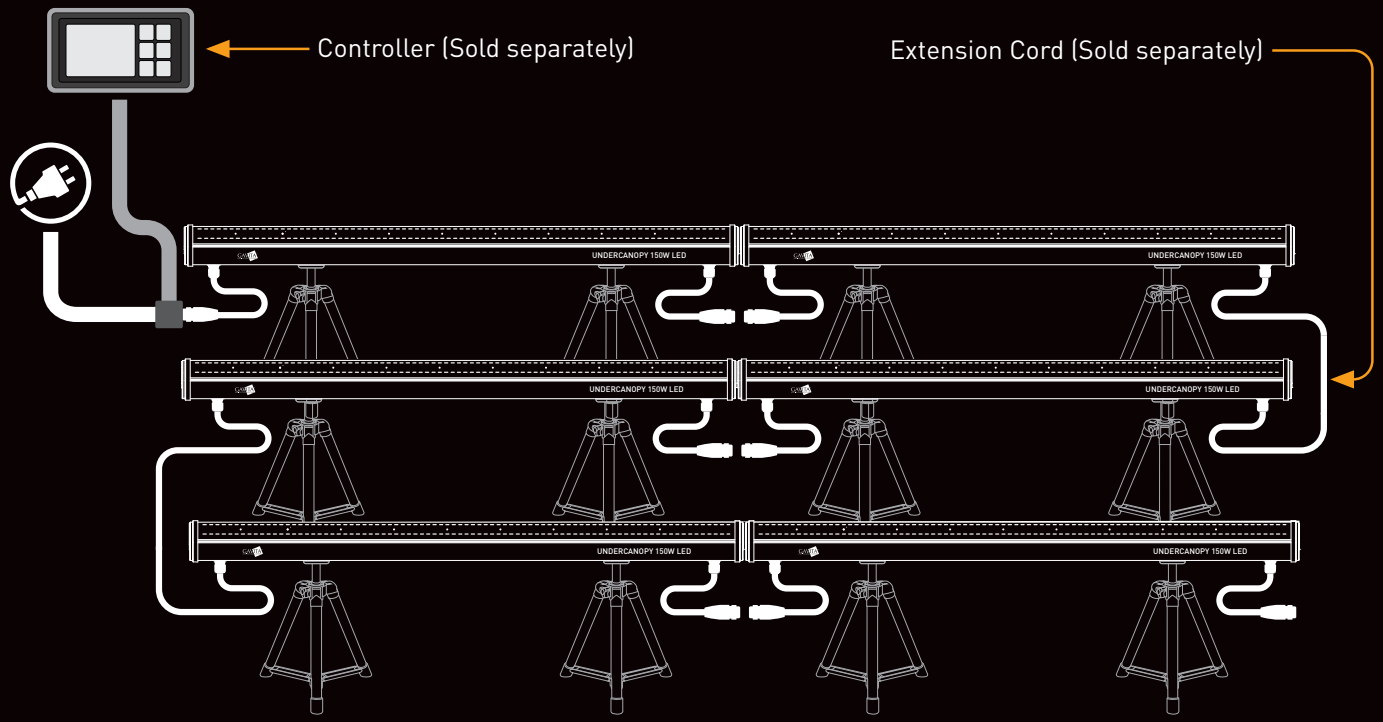


Ideally, a gradient-free light environment is needed for uniform growth through the entire canopy. While it is possible to reduce plant density or manually remove fan leaves in order to minimize shading and light gradients, these cultivation strategies reduce the overall output potential of a production area. To enhance operational efficiency, under-canopy lighting is an attractive solution. By placing a light source below the canopy to direct light upward, this approach minimizes the top-to-bottom light gradient and helps maintain the quality of developing buds throughout the entire canopy. While relatively new for cannabis cultivation[1], it has been proven successful in other horticultural crops such as cucumber[2], tomato[3] and leafy greens[4].

UNDER-CANOPY LIGHTING

CONFIGURATION AND OPERATIONAL GUIDELINES

Proper installation, operation, and maintenance are key to maximizing the performance of our Under-Canopy fixtures. These units are designed for straightforward setup using telescoping mounts and can be daisy-chained to accommodate various grow-room layouts.



They can be integrated into your existing control systems, with a 0-10V analog control signal, to manage on/off schedules and dimming, either in sync with your top lights or independently. For detailed instructions on mounting, electrical connections, control system integration, and cleaning procedures, please visit the dedicated product pages on our website. There, you'll find comprehensive guides and diagrams to ensure your fixtures are set up and operating correctly.

Photo Credit: Guerilla Grown Mic[illegible]an

Debunking The Leaf Light Myth:

Efficiency from Every Side

➔ There is a concern within the horticulture community related to the efficacy of light absorption and utilization by the lower surface of plant leaves. Some growers hypothesize that light illuminating the abaxial (bottom) side of a leaf would be less effectively used for photosynthesis due to factors such as stomatal distribution, cuticle thickness, and cellular arrangement. However, a pivotal scientific study[5] provided empiricalevidence to challenge this idea.

The research conclusively demonstrated that in conditions of saturating light intensity, photosynthetic rates were similar, irrespective of whether the illumination originated from the adaxial (top) or abaxial (bottom) surface of the leaf. This finding suggests that, when light is abundant, the internal photosynthetic machinery of the leaf is capable of efficiently processing photons regardless of their initial point of entry.

Illuminate Early, Grow Even:

The Gavita Timing Advantage

➔ Gavita R&D has conducted extensive research and numerous trials to determine the optimal timing for initiating under-canopy lighting in plant cultivation. Our findings demonstrate that the most appropriate and beneficial time to introduce supplemental light to the lower canopy is during the final week of the Vegetative growth stage.

This strategic timing is crucial for maximizing plant health, yield, and overall efficiency. Introducing under-canopy lighting at this stage allows the plants to acclimate to the increased light intensity before the upper canopy fully develops and casts significant shade on the lower foliage. Waiting until the lower canopy is already densely shaded by the expanding top canopy can lead to a detrimental situation. In such scenarios, the leaves at the bottom of the plant, which have adapted to lower light conditions, can experience a sudden and overwhelming onset of high light intensity.

This abrupt change can cause significant stress, leading to a range of physiological issues such as photoinhibition, nutrient lockout, and even tissue damage. By implementing under-canopy lighting in the late vegetative stage, cultivators can ensure a smoother transition, promoting consistent and healthy growth throughout the entire plant structure and preventing the potential for light-induced stress.

Light Below. Balance Above:

Under-Canopy lighting changes more than illumination.

➔ Implementing under-canopy lighting has the potential to impact environmental conditions in the grow room, primarily concerning thermal and humidity management. The added light inevitably translates into additional heat within the plant canopy. This increased heat load necessitates appropriate airflow to prevent issues such as localized hot spots which can cause heat stress to plants. Proper air circulation ensures that the heat generated by the lights is dissipated evenly throughout the growing area, preventing the formation of temperature gradients that could negatively impact plant health and uniformity. Beyond temperature, increased heat can also affect humidity levels. Without adequate ventilation, the air around the plants can become saturated with moisture transpired by the plants, leading to high humidity which can promote the onset of disease.

➔ Any increase in airflow to manage heat and humidity has the potential to impact irrigation strategies. Enhanced air movement around the plants, especially when coupled with higher temperatures, will invariably lead to increased transpiration rates. Transpiration is the process by which plants release water vapor through their leaves, and it is crucial for nutrient uptake and cooling.

However, elevated transpiration rates mean a higher demand for water from the root zone. Therefore, when implementing under-canopy lighting and ensuring sufficient airflow, attention must be paid to soil moisture levels and irrigation schedules. Growers may need to adjust their watering practices to provide more frequent or larger volumes of water to meet the elevated demands of the plants, preventing drought stress and ensuring optimal nutrient delivery.

Optimizing Toplight Intensity and Canopy Management with Under-Canopy Integration

➔ The implementation of under canopy lighting strategies will inevitably lead to adjustments in overhead, or "toplight," intensity. Preliminary R&D findings suggest a potential for optimizing energy consumption by integrating lower wattage toplight fixtures in conjunction with under canopy lighting systems. This approach is a major shift from traditional horticultural lighting: instead of attempting to force photons to penetrate the entirety of the plant canopy from a single overhead source, the goal becomes a more uniform distribution of light throughout the canopy layers. Further rigorous testing and experimentation are crucial to validate these initial observations and to precisely determine the optimal wattage ratio between toplight and under canopy fixtures.

➔ The adoption of under-canopy lighting technology presents an opportunity to adjust existing best practices for canopy management. A key benefit lies in the potential for a significant reduction of pruning and defoliation events. Traditionally, branches and leaves are removed in
order to improve light penetration to lower plant parts and enhance air circulation, both crucial for yield and plant health. However, these events are labor-intensive, require significant manual intervention, increase the potential for pathogen infection and can induce plant stress, potentially impacting growth cycles and overall productivity. With the deployment of under-canopy lights, the necessity for aggressive pruning and defoliation is diminished, especially to the bottom half of the plant canopy. These targeted light sources provide direct illumination to the lower and inner parts of the plant canopy, which would otherwise be shaded by the upper foliage. This ensures that all photosynthetically active parts of the plant receive adequate light, promoting more uniform growth and development throughout the entire plant structure.

A reduced need for defoliation translates directly into substantial labor savings. Fewer person-hours will be required for the physical act of removing leaves, freeing up valuable human resources that can be reallocated to other critical aspects of crop management, such as pest monitoring, disease prevention, or specialized harvesting techniques. Furthermore, minimizing defoliation events contributes to a less stressful environment for the plants. Every defoliation act, while necessary in traditional systems, is a form of abiotic stress. Reducing this stress can lead to more robust plant growth, enhanced nutrient uptake, and potentially improved resilience against environmental challenges. This holistic approach, integrating under-canopy lighting with revised canopy management, promises not only a reduction in labor but also a path towards more efficient, sustainable, and productive agricultural operations.

**All internal testing with under canopy lighting has been done in the CEC with type III cannabis*

Photo Credit: Skunkhouse in Michigan

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