



LEARN HOW TO GROW WITH LEDs

The Industry's Most Detailed
Guide for Professional LED
Growers



lumigrow

LED Growers' Guide

for CANNABIS

About This Guide

LumiGrow, a smart horticultural lighting company, has developed this guide, “How to Grow Cannabis with LED Grow Lights”, to instruct growers on how to use LED lighting strategies to maximize profits, boost yields, increase crop quality, and elicit desired plant characteristics. LumiGrow PhDs and Horticulturalists work with 3rd-party consultants to understand plant and light interactions, LumiGrow collaborates with some of North America’s leading horticultural institutions, and utilizes this knowledgebase to develop the industry’s most advanced lighting strategies.

Notes on Cannabis

Cannabis is undoubtedly shifting the horticultural industry’s focus as legalization of the high-value crop continues sweeping the world. Traditionally grown using guerilla agricultural tactics, cannabis cultivation is rapidly advancing to incorporate world-class technologies and practices.

As Cannabis enters a new era of cultivation where profit margin compression is driving competition, it has become crucial for growers to explore new strategies for boosting their bottom-line.

The key to success with an LED strategy is to change your cultivation ecosystem by rebalancing abiotic limiting factors to account for differences in light levels. This guide is your roadmap to addressing these limiting factors and deploying a successful LED strategy.

Contact a LumiGrow Lighting Specialist at
(800) 514-0487; lighting@lumigrow.com; or visit our
website for additional information at www.lumigrow.com



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The Basics of Horticultural Lighting

Horticultural lighting has remained rudimentary for the past 60 years. In the late 1950's and early 1960's, metal halide and high-pressure sodium (HPS) lights were developed. At that time, their high electrical efficiency, long life span, and relatively broad spectrum provided growers the best option in lighting.

The light emitting diode (LED) is the newest generation of lighting technology in the horticultural field. The first LEDs to emit visible light came in the early 1960's. The past 50+ years have seen many advancements in LED technology. Beginning with LEDs that barely produced enough light to see in a dark room, modern LEDs put out light levels that perform as well as any other horticultural lighting technology on the market. Just as HPS lights were once the most efficient, longest-lasting solution, LEDs now achieve the same horticultural lighting requirements with much higher efficiency and additional functionality. LEDs have advanced to produce 50% less electricity, release much less heat, are more stable over time, and are not hazardous to the environment.

Differences Between LED and HPS Lighting



HPS Lighting

In high pressure sodium (HPS) lit cultivations, flower development may be related to the temperature of the canopy, as well as other factors. We generally see top-heavy flower development within the canopy, usually to a depth of 18-24".



LED Lighting

With LumiGrow LED fixtures, this floral morphology becomes less distinctly "top heavy", as flowers develop more evenly across the vertical crop profile, creating the opportunity for greater total yield. Flowers grown under the LEDs see less variance in plant structure with up to 3 feet of consistent development compared to 18-24" seen with HPS. For this reason, it's important to adjust the temperature in your room to account for less heat, ultimately boosting yields and saving electricity.





Understanding Light's Characteristics

With LumiGrow smart horticultural lighting, growers have complete control over light intensity, light quality, and photoperiod. These three characteristics of light work together to direct plant growth and morphology, and ignoring any one characteristic can be detrimental to plant health. All of these characteristics must be considered when optimizing your grow space.



Intensity

is the amount of light supplied to the plant. Two ways to measure intensity are by using (Photosynthetic Photon Flux Density) PPFD and the Daily Light Integral (DLI).

- **PPFD** – An instantaneous measurement of the number of photons received by a plant that can be utilized for photosynthesis is called the photosynthetic photon flux density (PPFD), measured in micromoles per square meter per second ($\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$). PPFD is used to understand how much light a plant is receiving in any given moment, and is most often used for indoor cultivation where light fixtures are the only source of light.
- **DLI** – DLI is an important variable to measure in every greenhouse because it influences plant growth, development, yield, and quality. Much like a rain basin, where PPFD would be individual drops, DLI is a daily measurement of the number of photons received in a grow area that can be utilized for photosynthesis. DLI is calculated by looking at total PPFD over a 24-hour period, and is measured in $\text{mol}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$. It's especially important to think about light in terms of DLI when growing in a greenhouse where plants are receiving varying amounts of sunlight as well as supplemental lighting.

Calculating your ambient or supplemental DLI is easy using the following equation:

$$\text{DLI} = \frac{\text{intensity} * (3600 * \text{photoperiod})}{1,000,000}$$

Number of seconds in an hour

Average intensity in $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$

For ambient solar DLI, input hours of sunlight within 24-hour period

For supplemental DLI, input fixture runtime within 24-hour period





Quality

refers to the spectra or wavelengths of light that plants receive. Plants sense wavelengths from ultraviolet (UV) to far red light, 280-800nm, which is described as the range of Photo-Biologically Active Radiation (PBAR). The wavelengths ranging from 400-700nm are used for photosynthesis and are referred to as Photosynthetically Active Radiation or PAR.

With LumiGrow smart horticultural lighting, growers have complete control over light intensity, light quality, and photoperiod. These three characteristics of light work together to direct plant growth and morphology

Within PAR, blue light is typically defined as including the wavelengths from 400-500 nm, green light from 500-600 nm, and red light from 600-700 nm. In addition to driving photosynthesis, light quality is responsible for other plant responses, such as reducing internodal spacing, regulation of the circadian clock, flowering, crop morphology, as well as cannabinoid and terpene levels.

With LumiGrow lighting, light quality can be adjusted throughout the growth stages to control crop growth in a more precise way. It's important to note that wavelengths outside of the PAR range are used for secondary plant responses.





Photoperiod

is the duration of light a plant receives in a day. Plants are skilled at measuring the length of the day (light period) and the relationship of the day to the night (dark period). The response to the light-dark cycle is known as photoperiodism. Photoperiod manipulation is commonly used to steer plants from vegetative to reproductive growth.

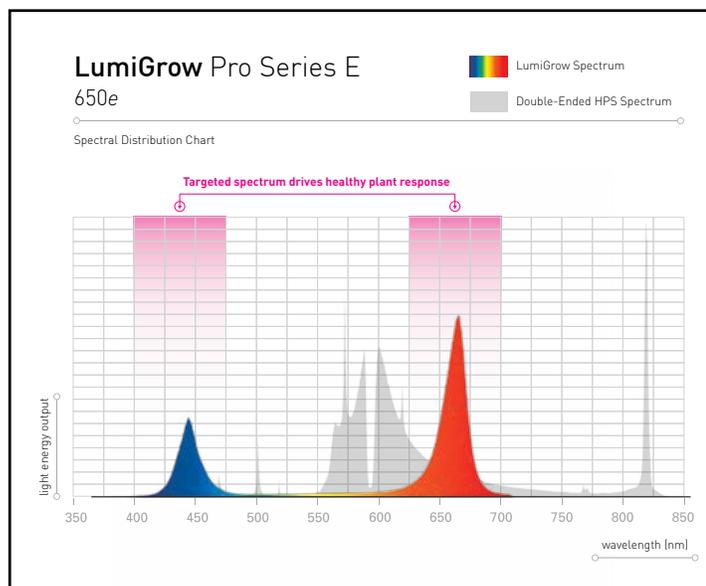
Cannabis is an obligate short-day plant, which means it flowers when the dark period is shifted to a critical length. This translates into a recommended 12 hour photoperiod when lighting cannabis for flowering and 18 hours a day in the vegetative phase.

LumiGrow Spectrum for Cannabis Growth

LumiGrow lighting solutions are designed to effectively support photosynthesis while offering dynamic spectrum control where specific spectral ratios can be created to direct plant growth and promote healthy plant development.

LumiGrow fixtures are engineered for both indoor (sole-source) and greenhouse cultivation, directing light within the Photosynthetically Active Radiation region, which refers to the light utilized by plants for photosynthesis.

For indoor cultivation, LumiGrow has included white light into our standard spectrum to provide for plant metabolic processes, while focusing light within red and blue PAR bands to drive photosynthesis. LumiGrow lighting strategies are also built to significantly reduce energy consumption and associated electrical infrastructure costs.





LumiGrow Spectrum for Greenhouse Cannabis Cultivations

LumiGrow spectrum is built with optimal photosynthesis in mind. Other LED manufacturers will often claim that they offer “full spectrum” lighting, similar to the sun’s spectrum. The truth is these lights are not actually “full solar spectrum” they often lack many wavelengths found in the full solar spectrum, including UVA, UVB, Far Red and IR. Creating a truly “full solar spectrum” light would actually be cost-prohibitive at this time for the production environment.

Also it’s important to understand that plants may not utilize a full-spectrum of light and selectively utilizes specific wavelengths. LumiGrow focuses our spectrum within the Photosynthetically Active Radiation region, also known as PAR, which is the light utilized for photosynthesis.

But even within the PAR range there are differences in the way plants utilize light spectrum. Much like the way humans utilize carbohydrates, fats, and protein differently, plants will utilize light wavelengths differently.

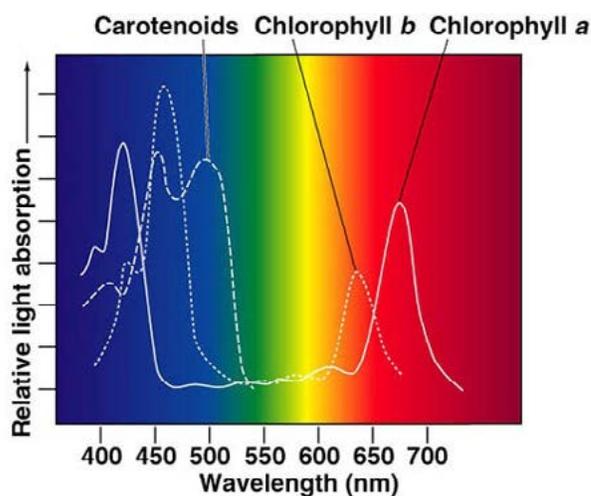


Figure 1 Absorption profile of A and B The light microscope. (n.d.). Retrieved February 21, 2018, from http://projects.ncsu.edu/project/bio183de/Lab/photosynthesis_lab/absorption2.html

Photosynthesis depends upon the absorption of light by pigments in the leaves of plants. These pigments being, chlorophyll-a and chlorophyll-b. As shown in the above graph, not all PAR light absorbs light equally in the PAR range.

By distributing light primarily within the red and blue wavelengths directed for photosynthesis, LumiGrow fixtures will optimize your energy expense by offering only the highest quality light, diverting your energy and money into the highest performing wavelengths while letting the sun fill out the rest.



Using LumiGrow Dynamic Spectrum for Precision Cannabis Growth

The human eye cannot perceive the subtle differences in light intensity that a plant can perceive. What appears to be a uniform light distribution to the human eye may not reflect an accurately uniform light distribution. Plants are much more sensitive to variation in light uniformity than humans and plant growth will reflect this lack of uniformity.

When using light quality as a tool for controlling plant growth, it is important to establish production requirements, and use light accordingly to achieve specific growth goals. In general, red light will increase stem elongation, while blue light promotes plant compactness and root growth, and is important for plant morphology, photosynthesis, and overall plant health.

When growing indoors it is important to have a mix of red and blue light, a lack of either of these important wavelengths can have adverse effects on plant morphology. Both red and blue light channels can be adjusted using LumiGrow's smartPAR™ Wireless Control System to alter your crops characteristics for precision crop growth that meets your cannabis production goals.

Important Environmental Considerations

LumiGrow develops the industry's best practices for optimizing light for your grow facility. So naturally, it's important to understand how other factors influence light performance.

Using Relative Humidity and Temperature to Optimize the Vapor Pressure Deficit in Your Environment for LED Light

From a basic point of view, temperature and relative humidity work together to affect plant transpiration. Relative humidity (RH) refers to the amount of water vapor in the air versus what it can hold at that temperature. The amount of water the air can hold is directly linked with temperature; where warmer air has a greater holding capacity than cooler air.

A useful tool for measuring these environmental factors is to manage your vapor pressure deficit (VPD). VPD is the difference between the amount of moisture in the air and how much moisture the air can potentially hold when it is saturated at a particular temperature. VPD can be used to predict transpiration and is a useful tool to help growers optimize the growth parameters in their cultivation.

A high VPD, measured in kilopascals, (greater than 1.0 kPa) indicates the air can potentially hold more water, meaning there is low moisture content in the air. This results in a large gradient





between the plants and the air, driving plants to transpire more .

A low VPD means that air has a high moisture content, thus reducing transpiration rate and impacting nutrient uptake. In addition to reducing transpiration, if VPD is too low then a film of water may form on the leaf surface making plants susceptible to disease. When properly managed, plants will transpire freely and move nutrients readily to cells and maximize CO₂ uptake.

Optimizing CO₂ for LED-lit Cultivation

CO₂ enrichment is used by many growers to increase photosynthesis and plant growth. LumiGrow recommends target CO₂ levels of 1,200 to 1,500 ppm in a production room. The rate of CO₂ uptake is increased when both air temperature and light intensity are increased. Research suggests that CO₂ concentrations above 1,200 to 1,500 ppm are typically not beneficial for the plant.

WHAT CANNABIS GROWERS ARE ACHIEVING W/ LEDS



Consistently high yields and premium quality, with large electrical infrastructure and operational savings



Easy management via LED software to control all grow rooms separately from the same device



Smart lighting strategies empower growers to boost terpenes, THC, and cannabinoids



Overall boost in ROI due to saving strategies and consistent cannabis production



Stay Rooted to Your Grow with smartPAR Wireless Control



Adjustable Spectrum

Enable adjustable spectrum for your LumiGrow LEDs, to elicit healthy plant response and maximize production



Automated Zones

Control your lighting with precision by setting up automated lighting zones, no wiring needed



Light Sensor Integration

Automate cannabis greenhouse lighting with sensor technology and access valuable analytics and reporting

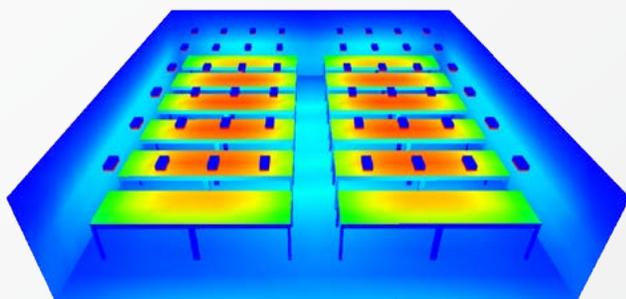


Considerations for Lighting Layouts

Reduce aisle space as much as possible

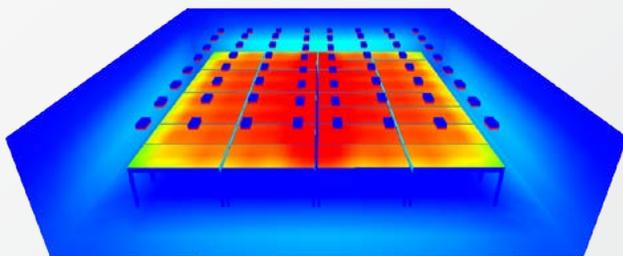
In order to maximize yield and efficiency, taking steps to optimize your growing space can make a large difference. Light placement is crucial to ensure uniformity and performance throughout the grow space. If light is not planned for and implemented correctly, there will be peaks and valleys of light intensity throughout in the room. Inconsistency in light can dramatically put plant growth in imbalance, with plants directly under light fixtures exposed to potentially damaging high light intensities, while plants further from the fixture receive inadequate light.

When the light that would have been lost to an aisle is captured by plants, your operation's efficiency and overall yield will increase. Consider that 1% of light generally equates to 1% yield.



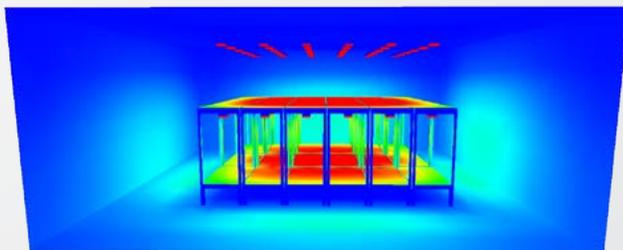
Static Benches

Many growers choose to use static benches to mitigate upfront costs. Still, it's important to keep in mind that the more space left for aisles, the more light (and electricity) will be lost to these aisles.



Rolling Benches

Rolling benches offer a larger surface area for efficient lighting deployment. With larger surface area, light can be deployed without losing light to the aisles, resulting in higher yields and better crop production efficiency.



Stacked Benches

Stacked benches are often the most costly cultivation strategy but can be useful for growers looking to optimize space. While higher yields can be achieved per square foot of space, it's important to note that higher electrical and infrastructure costs will be required to power your facility.



Lighting Requirements for Cannabis

LumiGrow provides lighting recommendations by growth stage, as lighting needs differ between plants in propagation, vegetative, flowering, and stock plant stages. We recommend that growers begin by using LumiGrow LED fixtures with standard spectrum settings. Growers can then adjust spectral ratios and test accordingly to optimize your grow for desired varieties and specific characteristics. Remember, when implementing a smart lighting strategy, it is important to treat light as any other variable and keep testing to determine conditions best for your varieties.

| |  Propagation & Cuttings 14 Days |  Vegetative Growth 21+ Days <i>Depending on strategy</i> |  Veg-to-Flower Transition 3-7 Days |  Flowering 8-10 Weeks <i>Including transition and depending on cultivar</i> |  Stock Plants (mothers) Slow Growth |  Stock Plants (mothers) Rapid Growth |
|--|--|--|---|--|--|---|
| Avg. Light Intensity <i>Measured in $\mu\text{mol m}^{-2} \text{s}^{-1}$</i> | 150-200 | 200 <i>Increasing gradually to 450-550 over 21 days</i> | 450-550 <i>Increasing to 700-800</i> | 700 - 800 | 350-450 | 500-600 |
| Photoperiod <i>Hours of light</i> | 18 | 18 | 12 | 12 | 18 | 18 |
| Ambient Room Temp. (Day) <i>F° C°</i> | 70-72 °F 21-23 °C | 80-85 °F 26-29 °C | 80-85 °F 26-29 °C | 80-85 °F 26-29 °C | 70-75 °F 21-24 °C | 80-85 °F 26-29 °C |
| Ambient Room Temp. (Night) <i>F° C°</i> | 60-70 °F 16-21 °C | 70-75 °F 21-24 °C | 70-75 °F 21-24 °C | 70-75 °F 21-24 °C | 65-70 °F 18-21 °C | 70-75 °F 21-24 °C |
| Ambient Relative Humidity (Day) <i>(RH)</i> | 100% <i>until rooted, within 4-7 days, then vent to 80%</i> | 75-80% <i>(early)</i> 55-67% <i>(mid/late veg)</i> | 55-67% | 55-67% <i>(early)</i> 50-62% <i>(mid/late flower)</i> | 50-60% | 55-67% |
| Ambient Relative Humidity (Night) | <i>Same as daytime, see "Propagation" section below for more information</i> | 75-80% <i>(early)</i> 55-67% <i>(mid/late veg)</i> | 55-67% | 55-67% <i>(early)</i> 42-57% <i>(mid/late flower)</i> | 50-60% | 55-67% |
| Vapor Pressure Deficit (Day) <i>(Measured in kPA)</i> | 0 | 0.67-1.00 <i>(early)</i> 1.11-1.80 <i>(late)</i> | 1.11-1.80 | 1.11-1.80 <i>(early)</i> 1.28-2.00 <i>(late)</i> | 1.00-1.49 | 1.11-1.80 |
| Vapor Pressure Deficit (Night) <i>(Measured in kPA)</i> | 0 | 0.50-0.75 <i>(day)</i> 0.82-1.34 <i>(night)</i> | 0.82-1.34 | 0.82-1.34 <i>(early)</i> 1.07-1.73 <i>(late)</i> | 0.83-1.24 | 0.82-1.34 |
| CO₂ Enrichment <i>(Measured in ppm)</i> | - | 1200-1500 | 1200-1500 | 1200-1500 | 0 | 1200-1500 |



LED Lighting By Growth Stage

Cannabis plants during propagation have different lighting requirements than those in vegetative growth.

Light PPFD - Propagation

- Rooted cuttings may be quickly acclimated to intense light. Cuttings can be started at intensities of 150 to 200 $\mu\text{mol m}^{-2} \text{s}^{-1}$.

Temperature & Humidity

- When rooting cuttings, ambient temperatures should be maintained at 70-72°F (21-23°C) for daytime temperatures, and 60-70°F (16-21°C) during nighttime.
- If using a humidity dome, temperatures under the dome will be warmer than ambient temperature.
- Cuttings should be grown in an environment with 100% humidity until rooted. After rooting RH should be gradually reduced to 80% by venting the humidity dome and later by completely removing it.

VPD

- Since cuttings are grown in an environment with 100% humidity until rooted, their VPD will remain at 0.

Light quality

- LumiGrow recommends growing cuttings under the LumiGrow's standard spectrum. Growers wishing to experiment with spectral strategies during this period may choose to increase the ratio of blue to red light. A higher ratio of blue light during the rooting phase has been shown to increase root growth in many species.





1.1 Recommendations for Transitioning

Recommendations for Transitioning from Propagation to Vegetative Growth

When transitioning plants from propagation to vegetative growth it is recommended to start the plants off at a lower light intensity, then gradually increase light intensity for several days as the plants adapt. With the smartPAR™ Wireless Control System, growers can create lighting schedules to easily adjust for intensity and slowly ramp up every day during this phase.

However, some growers have had success using a staged approach. You can start your vegetative growth cycle

at roughly $200 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ of light, then ramp up the lighting every 7 days for 21 days.

Pay attention to how well your plants are adapting. They will tell you through visual cues how much you should increase light intensity. If plants are quickly moved to a new environment they may show signs of stress including: leaf drooping, slow growth, or yellowing of leaves. If crops show signs of stress, lower light intensity accordingly to mitigate stress.

It is important not to change light intensity and spectrum at the same time during this transitional phase.



LED Lighting for Vegetative Growth

LumiGrow recommends the following lighting requirements for vegetative Cannabis growth.

Light PPFD - Vegetative

- Once plants reach an acceptable size and have sufficient root development, they should be transferred to the vegetative production area. LumiGrow recommends lighting plants starting with $200 \mu\text{mol m}^{-2} \text{s}^{-1}$, then gradually ramping up to $450\text{-}550 \mu\text{mol m}^{-2} \text{s}^{-1}$ over 21 days.
- Growers can use LumiGrow smartPAR™ software to create lighting schedules for their vegetative zones to gradually ramp up light intensity over the vegetative growth phase.



- During the vegetative stage LumiGrow recommends a photoperiod of 18 hours.

Temperature & Humidity

- Plants should be grown at temperatures of 80 to 85°F (26-29°C) during the day photoperiod and 70 to 75°F (21-24°C) during the 6 hour night period.
- Relative humidity should be 75-80% during early veg, and gradually transitioned to 55-67% as the plant canopy thickens.

Vapor Pressure Deficit

- Once the canopy begins to fill out, the RH is higher inside the canopy than what is typically measured outside of the canopy. For this reason, it's recommended that RH in late veg and early flower accounts for the difference between canopy RH and ambient.
- Plants grow best under a VPD of 0.67 to 1.80 kPa, depending on time of day and growth stage. For detailed VPD recommendations, reference the LumiGrow LED Lighting Card for Cannabis (page 13) .

CO₂

- CO₂ enrichment during vegetative growth is a useful tool to stimulate fast, healthy growth. CO₂ levels should be 1200 to 1500 ppm (exact level will fluctuate with air circulation).
- With CO₂ enrichment, LumiGrow recommends increasing room temperature to 85°F (29°C) and increasing the light intensity to the maximum intensity of 550 $\mu\text{mol m}^{-2} \text{s}^{-1}$.

Light Quality

- A spectral ratio with increased blue light can be used to promote compactness of “stretchy” varieties. This strategy can be used to control plant height by reducing node elongation, creating a thick dense canopy. A blue-light treatment may be useful for creating a greater density of plants in the grow area to maximize your vegetative space.



- Conversely, a high ratio of red light can be used to increase plant elongation. A red-light treatment may be useful for growers looking for rapid vertical growth. A higher red to blue spectral ratio will increase internode spacing, resulting in taller plants with more room for bud development.

It is important to note that adjusting light spectrum will impact light intensity. Since 75% of LumiGrow's Pro Series E fixture's light output is within the red wavelength, reducing light intensity from the red channel will dramatically reduce the overall light output of the fixture. The advantages of keeping your plants more compact should be weighed against decreasing the overall light intensity and growth rate.



1.1 Recommendations for Transitioning

Recommendations for Transitioning from Vegetative Growth to Flowering

Generally speaking, it is best not to change spectrum, light intensity, or photoperiod at the same time. Doing so may stress the plants and reducing plant growth rates.

If transitioning from a different spectrum to LED, try to match the light intensity of your vegetative growth room, then increase light

intensity to full power over 2 to 3 days.

Some growers like to finish the last 3 to 7 days of their vegetative growth cycle under the LEDs in their flower rooms. If implementing this strategy, use the smartPAR™ Wireless Control System to dial the intensity of your flower room down to match your vegetative growth room. Then change the photoperiod to 12 hours and increase to full light intensity over 2 to 3 days.

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(800) 514-0487; lighting@lumigrow.com; or visit our
website for additional information at www.lumigrow.com





LumiGrow recommends the following lighting requirements for flowering cannabis growth.

Light PPFD - Flowering

- Light is exceptionally important during the flowering stage to ensure maximum possible yield. Light intensities should remain high during this stage, 700-800 $\mu\text{mol m}^{-2} \text{s}^{-1}$. In general, higher light intensities result in increased growth and yield.
- It is important to maintain an exact 12-hour photoperiod during flowering. If plants receive a longer photoperiod they will remain in a vegetative state. Growers should remain cautious of any additional light past 12-hours, as even short intervals of any light at low intensities (2-5 $\mu\text{mol m}^{-2} \text{s}^{-1}$) are enough to delay flowering. Even wavelengths considered to be safe, like green light, can compromise flowering to some extent.

Temperature & Humidity

- LumiGrow recommends maintaining a temperature of approximately 80-85°F (26-29°C) during the photoperiod dropping to 70-75°F (21-24°C) for the night period. This higher temperature during the day with a distinct temperature drop for the night will balance plant growth and promote robust flowering.
- Relative humidity should be maintained at 55-67% during early flowering, then transitioning to 50-62% for mid-late flowering.
- When plants are first moved into the flowering room the humidity should stay on the lower end of the range. After flowers have developed, the humidity can be increased.

Vapor Pressure Deficit

- Like relative humidity, the VPD should initially remain the same as used during vegetative growth (1.18 to 1.80 kPa), then increase to 1.30 to 2.00 kPa as flowers develop.

CO₂

- Growers should enrich with CO₂ to stimulate photosynthesis and enhance plant growth. CO₂ uptake and assimilation are closely tied to light and temperature.
- LumiGrow recommends enriching from 1200 to 1500 ppm.



Light Quality

- Lighting with a higher ratio of blue can be used to promote more compact growth. This strategy can be useful for preventing taller varieties from lodging.
- Additionally, dynamic spectral control can be used to improve bud flavor, aroma, and profitability of your cannabis product by increasing terpene concentrations. Terpenes are aromatic compounds that give cannabis some of its more distinct aromas from citrus and berry, to more earthy tones.
- **Research has shown that for many varieties, terpene concentration can be increased by lighting plants with blue light alone for the final 72 hours of production. Growers can use smartPAR™ to adjust your LumiGrow fixtures to all-blue light output for the final 3 days of production.**



LED Lighting for Stock Plants (Mothers)

LumiGrow smart lighting strategies make it possible for growers to manage their stock plants more easily, as well as produce cuttings tailor-made for their specific cultivation applications.

Light PPF - Stock Plants (Mothers) - Slow Growth

- For high-quality stock plants kept at a slow growth rate, LumiGrow fixtures should be set to intensities of 350 to 450 $\mu\text{mol m}^{-2} \text{s}^{-1}$ with a photoperiod of 18 hours.

Temperature & Humidity

- Daytime temperature should be maintained at 70-75°F (21-24°C), with a RH of 50-60%

Vapor Pressure Deficit

- LumiGrow recommends a VPD of 1.00-1.49 kPa in the day, with 0.83-1.24 kPa at night.

CO₂

- CO₂ enrichment can be used to increase the growth of stock plants, allowing more plant material for cuttings.
- If the need for cuttings is delayed, then the slow-growth strategy should be used. CO₂ enrichment should be stopped, and intensities and temperatures should be lowered to



- the bottom end of the acceptable range. This strategy reduces overall plant growth and saves energy and labor.

Light Quality

- Light spectrum can be adjusted using LumiGrow smart horticultural lighting to control the length of internodes for cuttings. A spectral ratio with increased blue light can be used to promote compact growth by reducing node elongation. This strategy can be used to control plant height, while creating a thick dense canopy.
- Conversely, a high ratio of red light can be used to increase node elongation resulting in a longer cutting.

Light PPFD - Stock Plants (Mothers) - Fast Growth

- For high-quality stock plants kept at a slow growth rate, LumiGrow fixtures should be set to intensities of 500 to 600 $\mu\text{mol m}^{-2} \text{s}^{-1}$ with a photoperiod of 18 hours.

Temperature & Humidity

- Adjust temperatures to 80-85°F (24-29°C) if enriching with CO₂ during the day and between 70 -75°F (21-24°C) at night. It is important to keep night time temperatures cooler than day temperatures.

Vapor Pressure Deficit

- LumiGrow recommends a VPD of 1.11-1.80 kPa in the day, with 0.82-1.34 kPa at night.

CO₂

- When enriching with CO₂ concentrations of 1200 to 1500 ppm, temperature and intensity can be increased to further boost growth. Room temperature can be increased to 85°F (29°C) and light can be increased to the maximum intensity allowable by the lighting conditions.



Importance of Genetics

Overview of genetics among varieties

It is always important to start with healthy, fast-growing genetics.

The genus cannabis has three distinct species of s: *C. sativa*, *C. indica*, or *C. ruderalis*. Most commercial and medicinal varieties are *C. sativa*, *C. indica* or a hybrid of these two. The specific make-up of a variety determines its potency, flavor, and aroma, as well as its growth habits. Cannabis indica varieties tend to be more compact, while *C. sativa* varieties grow taller and have larger internodes. Certain varieties may exhibit difference in cycle time and flower production.

Importance of testing varieties when changing cultivation strategies

Different varieties perform differently under different growing conditions, and light is no exception. Under different LED spectral ratios, varieties may perform in a manner differently. Similarly, different varieties will perform differently under LED versus how they perform under high-pressure sodium lamps. When changing lighting strategies, it is important to test varieties before starting full-scale production.

Many current varieties have been selected for production with high-pressure sodium lamps, as LEDs become the standard lighting technology, more varieties are being selected for their favorable performance under LEDs.

When switching to LEDs, growers may see differences in plant growth or production timing. Certain varieties may grow better under LEDs, while other varieties may experience reduced yield. If possible, growers should trial several varieties under LEDs, keeping track of production times, yield, and THC levels, then select high performing varieties.



Indica



Sativa





lumigrow

Growth Through Connectivity

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LED Growers' Guide

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