Using Spectral Control For Cannabis Cultivation

A simple how-to guide for using spectral science to realize more yield, higher quality, and elicit desired crop characteristics

Ready to Harness Spectral Science?
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www.lumigrow.com
Notes from the LumiGrow Research Team

The Spectral Control Guide was created by the LumiGrow Research Team to outline factors that should be considered when using spectrum control to grow Cannabis in a sole source environment.

Working in-house and with research partners LumiGrow has discovered myriad ways in which light can be used to influence crop characteristics. Through this cooperative research, findings have been quickly and efficiently adopted as commercially viable solutions by LumiGrow partners.

Spectral science trials have been conducted for a range of Cannabis varieties with the purpose of improving plant growth and quality. The recommendations provided in this guide are based on the knowledge gained from these trials and reveal some ways in which spectrum control can be used for Cannabis cultivation.

Disclaimer
A wide range of Cannabis phenotypes are grown commercially. It is important to remember that results will vary among Cannabis varieties.

Important Considerations When Using LumiGrow LED Lighting

LumiGrow fixtures offer easier control over temperature and relative humidity, which provides the opportunity to grow a thicker, fuller canopy. Before using your LumiGrow fixtures, please consider the following as it relates to these advantages:

Infra-Red wavelengths emanating from HID lamps generate an excess of heat in the upper canopy. As a result, HID-lit gardens have a steep temperature gradient through the canopy, resulting in most of the growth occurring in the upper canopy where temperatures are higher. Lower in the canopy, flower development is often negligible because of cooler temperatures and inconsequential light. Because of this uneven flower development, growers usually trim stems away from the lower canopy using a method referred to as “lollipopping”.

In contrast to canopy development under an HID, cool-running LEDs provide a lower, more consistent temperature throughout the plant canopy. This temperature consistency allows for uniform development of flowers throughout the vertical profile of the canopy. This occurs as a result of the growing tips having a similar temperature and metabolism. Also contributing to a more even canopy development, the intense red and blue light from LumiGrow LEDs penetrates the canopy to a greater depth than HID light, allowing for a greater vertical distribution of photosynthesis and flower development.

Because the average leaf temperature is lower under LEDs, LumiGrow recommends raising the ambient grow room temperature 5 degrees F. This approximates the increase in temperature of leaves under HID lamps and will lead to robust and more consistent flower development for all areas of the canopy. Together, a more even temperature distribution within the canopy and greater light penetration result in the potential for a much “thicker” canopy with a more even distribution of flowers. In contrast to the typical 18” of canopy grown under HID lamps, up to 3 feet of solid flower development may be achieved with LumiGrow LED fixtures.

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Basic Introduction to Spectral Ratio Tuning

Note: Growers using spectral control strategies must have a quality PAR meter that effectively reads LED lights. We recommend meters made by LICOR, Ocean Optics, Apogee Instruments, or any PAR meter that can read the 400nm-700nm range.

1.1 What is Spectral Science and Spectral Control?

Spectral science is a quickly advancing discipline that's being successfully used by commercial growers around the world. Decades of investigation have led to an understanding of how plants perceive specific wavelengths of light to direct growth. These sensitivities include wavelengths both inside and outside of what is considered the Photosynthetically Active Radiation (PAR) action spectrum (400-700nm).

“Spectral Control” is the process wherein discreet wavelengths of light are adjusted relative to one another to give a ratio that will elicit a desired response from the plant in regards to development. LumiGrow fixtures allow for independent control of red, blue, and white light within the fixture, to give the operator greater control over plant characteristics, morphology and flowering.

An example of a spectral control strategy is the practice of reducing red light to zero during the final 3 days of flower maturation for Cannabis. This practice has been demonstrated by the LumiGrow Research Team to allow for increased terpene accumulation in Cannabis flowers. This setting radically changes the ratio of red to blue light, affecting metabolic functions within the plant that cause greater accumulation of terpenes that have value for flavor and medical applications.

Interested In This Research? Download the Paper from www.lumigrow.com
The Optimal Balance of Light

The “full-intensity” settings (all channels set to 10, or to 100%) for LumiGrow fixtures give a spectral ratio of 7:2:1 (Red: Blue: Green). This full-intensity setting is optimized for driving photosynthesis, and normal plant growth and development. Light intensity is often the limiting factor in indoor production. For this reason, the full-intensity settings on LumiGrow fixtures have been designed to work extremely well for most crops, including Cannabis. Before implementing a spectral control strategy, a grower must consider the effect that adjusting any channels on the lamps will have on overall light intensity. Any time a channel is reduced from full power there will be a reduction in the overall intensity of light emitted from the lamps. This must be weighed against the potential benefit that spectral control offers.

The degree to which plants are sensitive to changes in the fixture’s light spectra ratios is specific to the species and must be determined experimentally. LumiGrow is constantly performing trials to increase our knowledge-base in this regard. Currently we have determined that C. sativa, C. indica, and mixed varieties of Cannabis that include C. ruderalis all appear to have a “medium sensitivity” to spectral ratio changes and may be successfully manipulated to affect plant growth and development.

Specific adjustments to the three channels of the LumiGrow fixtures may be used for manipulating plant growth during distinct phases of plant development as outlined in the following sections. The following settings are based on measurements taken with a LumiGrow Pro650 fixture 30” above the plant canopy, unless otherwise stated. These are not absolute rules, but recommendations based on extensive research trials of approximately 50 varieties of Cannabis that have a great degree of phenotypic variation. Cannabis varieties we have tested respond to spectral control to varying degrees.
1.2 Considering photosynthetic requirements for growth

It is important to consider that plants need both blue and red light for healthy growth and maintenance of the photosynthetic machinery that makes growth possible. Because of this, eliminating either blue or red light completely will slow down growth, yet is frequently desirable for a brief part of the growing cycle to achieve other desired effects of a “no blue light” or “no red light” treatment. Small quantities of blue and red light are present in the white light that is included in the LumiGrow LED fixture’s arrays, and will help maintain some level of photosynthesis. However, the operator may want to consider making spectrum adjustments without turning a blue or red channel completely off. The desired outcome might be less dramatic, but robust growth would continue.
1.3 Using LumiGrow fixtures at full intensity

Using full power settings for all three channels (Red, Blue, White) will result in excellent growth that will resemble growth under a Metal Halide or High Pressure Sodium fixture. This applies to all stages of development from rooting of cuttings through flowering.

With all dials set to 10 (red, blue, white), the distribution of light is as follows:

- Blue (400-500nm): 18%
- Green (501-600nm): 13%
- Red (601-700nm): 69%

The full intensity spectral ratio is approximately **2:1:7 (B: G: R)**

The term “standard ratio” may be used to describe having all the channels at the same setting even if that setting is not 10 on the channel. For example, having all channels at 3 for rooting cuttings under a LumiGrow Pro 650 or Pro 650e may be described as using the “standard ratio” because the ratio of blue, red, and green will remain the same as it would if all dials were set at 10.

**SmartPAR Settings**

[Image of LumiGrow SmartPAR Settings interface]
1.4 Rooting cuttings with LumiGrow fixtures

Maintaining an optimal spectral ratio while reducing light intensity to a degree suitable for rooting cuttings is a precision task. A quality PAR meter must be used. Precision is especially important for the rooting process due to the sensitivity of unrooted cuttings to light.

LumiGrow recommends 100 µmol/m²/sec-¹ at canopy height for rooting Cannabis cuttings under standard rooting conditions. The optimal light intensity for rooting will vary depending on Cannabis variety, due to the high degree of diversity within the Cannabis genus. Regardless, the 100 µmol/m²/sec-¹ has worked well for all varieties tested to date.

To achieve 100 µmol/m²/sec-¹ of full intensity light at canopy height without a PAR meter: Using a Pro 325 or Pro 325e, adjust the height of the bottom surface of the fixture to 3’ above the surface that the cutting tray will sit on. Set all three channels to 4.

A “standard ratio” intensity is maintained if all channels are turned to the same setting. While “standard ratio” intensity settings will work well for rooting cuttings, further enhanced root development may be desirable. Reducing red light (effectively increasing blue light) will encourage robust root development while limiting stem stretching after rooting begins. Using a Pro 325 or Pro 325e, we recommend the following settings for optimum root development (this is the highest intensity you can achieve with the fixture while achieving this ratio).

Set your LumiGrow fixture’s spectral channels to:

- **Red**: 25% of channel’s output
- **Blue**: 100% of channel’s output
- **White**: 85% of channel’s output

*These settings provide a ratio of approximately 2:1:3 (B: G: R)*
1.5 **Vegetative growth with LumiGrow fixtures (production and mother plants):**

If the cultivar being grown frequently exhibits unwanted stretching, reducing red light will result in a more compact plant with shorter internode spacing. An additional benefit of reducing red light will be enhanced root development. LumiGrow makes the following recommendations for compact vegetative growth. (Remember reduction in light may result in reduced growth. *If growth has not been unfavorably affected, red light may be reduced further as needed*)

**Set your LumiGrow fixture’s spectral channels to:**

- **Red:** 50% of channel's output
- **Blue:** 100% of channel's output
- **White:** 100% of channel's output

*To create a ratio of approximately 1.8:1.3:3.45 (B:G:R)*
1.6 Flowering with LumiGrow fixtures:

Because the average leaf temperature is lower under LEDs, LumiGrow recommends raising the ambient grow room temperature 5 degrees F. This approximates the increase in temperature of leaves under HID lamps and will lead to robust and more consistent flower development for all areas of the canopy.

If it is desirable to reduce the time to flowering period, then reducing blue light may shorten the flowering phase of growth by up to 10%. This reduction in flowering time will typically result in a reduction in yield, so we only recommend using spectral control for this purpose if it is absolutely imperative that flowering time be shortened. For reduced flowering time, we recommend the following settings:
(This recommendation is based on 3rd party testing done outside of the LumiGrow Lab)

Set your LumiGrow fixture’s spectral channels to:

- **Red**: 100% of channel's output
- **Blue**: 20% of channel's output
- **White**: 100% of channel's output

To create a ratio of approximately 0.36:1.3:6.9 (B:G:R)

**SmartPAR Settings**
1.7 Driving Terpene Synthesis:

Cannabis flowers produce copious quantities of terpenes when grown with all channels set at standard-intensity. If even higher levels of terpenes are desired, it is possible to drive terpene synthesis using blue-light heavy spectral ratios. This will decrease overall growth of flowers, so these settings should only be used during late flowering when flower development is complete. We recommend using blue light to drive terpene synthesis only for 48-96 hours before harvest. The settings we recommend are:

Set your LumiGrow fixture’s spectral channels to:

- Red: 0% of channel's output
- Blue: 100% of channel's output
- White: 100% of channel's output

To create a ratio of approximately 1.8:1.3:0 (B:G:R)

SmartPAR Settings
Pro Series E
LED Lighting Systems

Enabled with SmartPAR™ Wireless Software Control
Each LumiGrow Pro Series E fixture comes with a SmartPAR™ Wireless Control Device. Now you can control the light intensity, spectrum and photoperiod of your lighting system from your phone, tablet, or computer. Automate your system on your own schedule, easily and with little setup required.

Features and Benefits
- Achieve up to 70% in energy savings versus HID
- Unleash “light as a growth variable” with full spectrum control
- Runs up to 70% cooler than HID lighting
- Small hardware footprint to minimize plant canopy shadowing
- RoHS Compliant (mercury and lead-free)
- cUL / UL and CE certified
- 5 – Year Warranty
- White Light View Mode
- Maintains light output longer than HID

Applications
- Greenhouse horticulture
- Indoor cultivation
- Research greenhouses

Installation
- Once your network is installed by a certified LumiGrow professional, using SmartPAR™ is as simple as:
  1. Access the SmartPAR URL on your device
  2. Log in to your secure LumiGrow portal
  3. Begin controlling your lights from anywhere

Get More Light With Less Energy
LumiGrow’s lights are designed to emit a targeted spectral output to trigger healthy plant responses, boost yield, and reduce your energy costs. The diagram below shows how 100% of the light output from LumiGrow fixtures is optimal for plants, compared to the less efficient light that’s produced by most HID lights on the market.

<table>
<thead>
<tr>
<th>WAVELENGTH (nm)</th>
<th>LIGHT ENERGY OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>350</td>
<td>100W HPS</td>
</tr>
<tr>
<td>400</td>
<td>LUMIGROW PRO 650e</td>
</tr>
<tr>
<td>500</td>
<td>LUMIGROW PRO 325e</td>
</tr>
<tr>
<td>600</td>
<td>Targeted spectrum drives photosynthesis while eliciting healthy plant response.</td>
</tr>
<tr>
<td>700</td>
<td>HID light output is NOT optimal for photosynthesis.</td>
</tr>
</tbody>
</table>

Targeted spectrum drives photosynthesis while eliciting healthy plant response.

Pro Series E Spectral Output

<table>
<thead>
<tr>
<th>Spectral Output</th>
<th>Blue Light (400-500nm)</th>
<th>Green Light (501-600nm)</th>
<th>Red Light (601-700nm)</th>
<th>Total Photon Flux</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pro Series E</td>
<td>20.0%</td>
<td>5.0%</td>
<td>75.0%</td>
<td>100%</td>
</tr>
<tr>
<td>Photon Efficacy</td>
<td></td>
<td></td>
<td></td>
<td>1.9 uMol/Joule</td>
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LumiGrow was founded in 2007 with the sole purpose of building a world class LED horticultural lighting solution that enables growers and researchers to manage efficiency, yield, and plant characteristics. Our state of the art hardware LED grow lights emits a targeted spectral output to trigger healthy plant responses, boost yield, and reduce your energy costs.

Our SmartPAR™ wireless control system enables you to control the light intensity, spectrum, and photoperiod of your lighting system from your phone tablet, or computer. To begin automating your lighting system on your schedule, easily and with little setup required, contact a LumiGrow Account Executive.

Ready to harness spectral science? Visit our website.
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