GrowRay Spectrum by Dr. Erico Mattos

Plants can perceive and adapt to their environmental surroundings for optimal growth and development. Illumination is the most powerful environmental stimulus for plant growth and plants have sophisticated sensing systems to monitor light quantity, quality, direction and duration. Pigments and photoreceptors present on plants are responsible for controlling plant photosynthetic and photomorphogenic processes.

The range of light capable to induce photosynthesis in plants is called “photosynthetically active radiation” (PAR) and it is defined as radiation over the spectral range of 400 – 700nm. Every absorbed photon regardless of its wavelength contributes equally to the photosynthetic process. The range of light capable of inducing photomorphogenic process ranges from 350 – 750nm. Photomorphogenic processes play a major role in developmental programs that develop new tissues. The common unit of measurement for PAR is photosynthetic photon flux density (PPFD), measured in units of moles per square meter per second.

The plant’s metabolite production is also influenced by light spectrum. In addition to the primary metabolites of carbohydrates and amino-acids, secondary metabolites are also influenced by light quality. Many secondary metabolites are key components for plants defensive mechanisms and contributors to odors, tastes and colors. At this point little is known about the manipulation of these secondary metabolites under artificial illumination systems. *But what is known is that restricting the light spectrum to a handful of wavelengths can be detrimental for plant development.*

Using LED technology allow us to manipulate the light spectrum to trigger potential benefits in indoor cannabis production systems. In indoor cultivation systems it is possible to create a custom designed light spectrum to control plants’ development cycle, increase Favonoid and Terpene production, and enhance both biomass and THC production.

Beyond the benefits offered by LED technology, GrowRay™ exploits the advantage of LEDs’ controllability. Using a combination of full spectrum emitters along with specially selected monochromatic LEDs, GrowRay LED fixtures can control a plant’s developmental pathways by stimulating photomorphogenic processes, and at the same time maximize biomass production through the photosynthetic process. As a result, growers will have the benefits of more than 20 years of expertise in indoor plants control systems at the click of a button.

Importance of Full spectrum

The use of red and blue LEDs has been largely adopted by LED lighting companies as these wavelengths are efficiently absorbed by plants main photosynthetic pigments chlorophyll *a* and *b* (Fig A). These companies claim that blue and red LEDs alone are sufficient for horticultural applications, however in reality the situation is more complicated. Although chlorophylls are the main pigments found in higher plants, other pigments present on leaves are also capable of absorbing light and in conjunction with chlorophylls they extend the intact leaf's absorption spectra that are capable of inducing photosynthesis.

Most importantly, the additional spectrum drives secondary metabolisms necessary for healthy plant development (Fig B). As a result, a wide range of wavelengths can (and should!) be absorbed. Unlike pigments extraction solutions, in intact leaves, the "weakly" absorbed green-yellow wavelengths (500 – 600nm) bounce around the individual cells and are highly reflected by the water-air interfaces increasing their absorption inside the leaves. Furthermore, the higher penetration of green light compared to red and blue lights results in higher photosynthetic activity induced by green light in deeper layers of the leaf. The right balance of light quantity and quality should be achieved to promote the highest energy efficiency while ensuring healthy plant development and maximum biomass production.

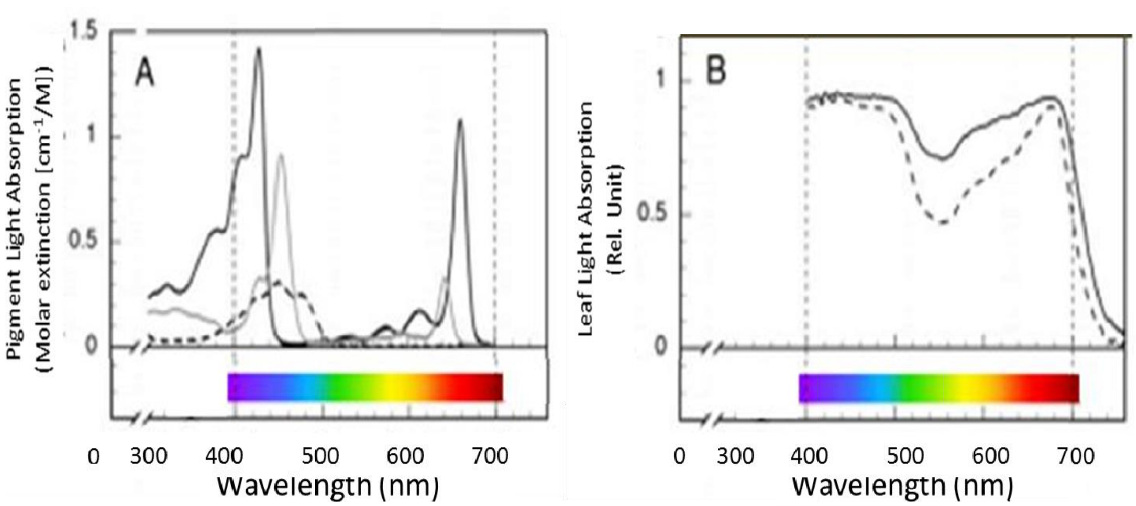


Fig A: Absorption spectrum of isolated pigments chlorophyll a (black line), chlorophyll b (gray line) and β–carotene (dashed line). Fig B: Light absorption in *Chrysanthemum morifolium*; fresh leaf (black line) and vacuum infiltrated by water (dashed line) to eliminate light scattering. -- *HortScience 50(8): 1128-1135. 2015*

Plant Development

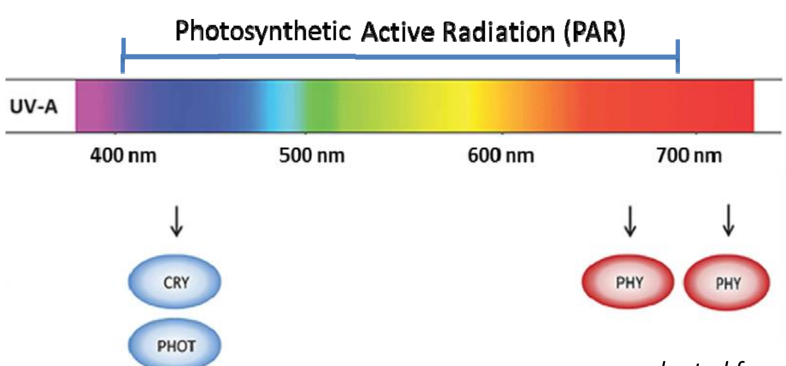
In addition to using chlorophyll and carotenoids for photosynthesis, plants use other photopigments for a wide variety of functions. Photomorphogenesis is the process of light-mediated plant development. Plants can sense light quantity, quality, direction and duration through a variety of photoreceptors which play a major role in developmental processes that generate new tissues (e.g. flowers and leaves). The most important photoreceptors present on higher plants are the Phytochromes, Cryptochromes, and Phototrophins.

The **phytochromes** respond to the ratio of red (660 – 670nm) and far-red (725 – 735nm) light. Phytochromes are synthesized in the dark in the P_r form and following the conversion to the P_{fr} form, they move to the nucleus. Red light (660 nm) causes conversation of P_r to biologically active P_{fr} form and far-red light (730 nm) the conversation back to P_r form. Phytochromes influence several aspects of plants development including flowering, seed germination, de-etiolation, stem elongation, cell expansion, shade avoidance responses, and photoperiodism. Many of these events are related to alterations in plants hormone levels and growth regulators. These changes then cause alterations in plants' morphology, physiology, development and metabolism.

The **cryptochromes & phototrophins** respond mainly to blue light (380 – 470nm). Cryptochromes have profound effect on seedling development and flowering. Among several plant growth responses, the most well know parameters influenced by cryptochromes are de-etiolation and photoperiodic flowering control. Phototrophins contribute to plant form and function (e.g. chloroplast and leaf movement, stomatal opening) and unlike the general effects of cryptochromes, the plants responses guided by phototrophins are all directly or indirectly related to optimizing photosynthesis.

Photosynthesis

The main pigments present at indoor cultivated plants are the chlorophylls and carotenoids. The light energy intercepted by these pigments directly fuels the photosynthetic process of CO_2 and water conversion into biomass. To stimulate high biomass production without significantly affecting plants' photomorphogenesis, light between 500 – 600nm can be used to charge the photosynthetic apparatus without stimulating the photoreceptors controlled by blue, red and far-red wavelengths.

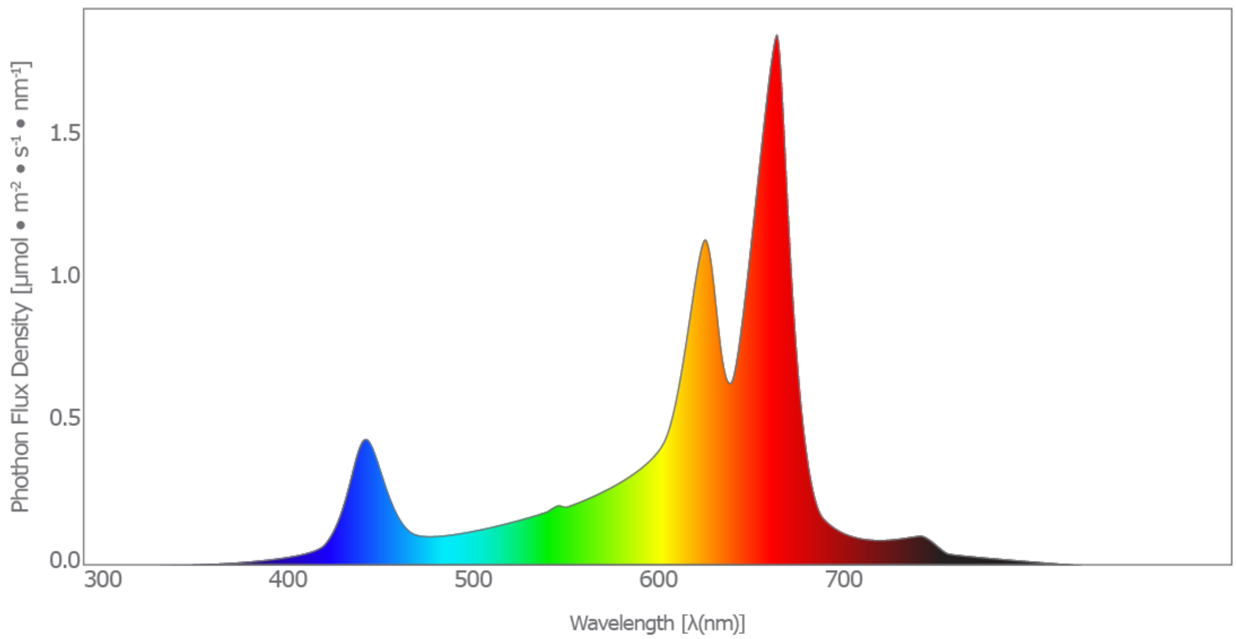


CRY: Cryptochromes
PHOT: Phototrophins
PHY: Phytochromes

adapted from: Front. Plant Sci. **5**:534. doi:

GrowRay Spectrum

To achieve maximum biomass production with less energy consumption and ensure healthy plant development, Grow- Ray™ has designed a custom light balance taking advantage of the latest LED technology. The specially formulated light balance regulates key plants developmental process while maximizing photosynthesis. Using especially selected wavelengths at red (660nm), blue (450nm) and far-red (730nm) combined with the full spectrum warm white LEDs, our spectrum can control plant flowering, photoperiod, leaf expansion, and plant shape while ensuring maximum biomass production.



Blue light: The selected blue LEDs present in Grow-Ray™ lights affect leaf movement leading to flatter leaves which result in a more efficient surface for light absorption. It also encourages fast leaf expansion resulting in larger surfaces for light absorption and photosynthetic activity. Another very important attribute of the blue is related to the stomatal activity regulation. Stomata are little apertures on the leaf surface which allow for CO2 to move inside the leaf. Higher concentrations of CO2 inside the leaf induce higher rates of carbon fixation and biomass production. The blue light induces stomata opening and allows for higher fluxes of CO2 inside the leaf.

Red light: The main photosynthetic pigment present in plants, the Chlorophyll *a*, has its light absorption peak at 660nm (red spectrum). LEDs in this wavelength are also part of the Bloom-Ray™ and Side-Ray™ lights. Using the red LEDs Grow-Ray™ lights provide higher PAR values at lower energy consumption, maximizing the lighting system energy use efficiency. Red light (together with far-red light) also induces the photoreceptors responsible for flowering and photoperiod regulation, the Phytochromes.

Far-Red: Grow-Ray™ is pioneering the use of Far-red emitters in commercial LED lights. Bloom-Ray™ lights are equipped with supplemental Far-red LEDs that in conjunction with the red LEDs provide light at the phytochromes absorption peaks. Controlling the duration and ratio of red/far-red light makes it possible to control plant behavior to increase biomass production and accelerate plant growth.

Day Use Recommendation: The far-red light provided by GrowRay™ increases photosynthetic efficiency avoiding energy imbalances that can occur inside the photosynthetic apparatus under high-light conditions. It allows the plants to convert more light energy into chemical energy which is required for biomass production and plant growth.

End of the Day Recommendation: (Research project under way to provide scientific data) Cannabis plants flowering process is regulated by a process called the photoperiod. The Cannabis photoperiod requires a minimum of 12 hours of darkness to flower. This process is controlled by the phytochrome photoreceptors. GrowRay™ far-red emitters can be used to manipulate phytochrome response and trigger the plants into shorter dark periods and provide additional time for more flowering.

Warm-White: All GrowRay™ lights are equipped with white LEDs which deliver full spectrum light to ensure primary and secondary metabolite production. GrowRay™ warm white LEDs are selected to match the required spectrum for optimal plants development at veg and flowering stages. The white lights provide a constant full spectrum light supply allowing for plants' photomorphogenic processes to be controlled by individual blue, red and far-red emitter manipulation without compromising plants' photosynthetic activity. It ensures the required light flux to maintain optimum light energy conversion throughout the entire plant growth cycle.

Far-Red Spectrum: The warm white LEDs used by GrowRay™ lights ensure the delivery of a small amount of far- red radiation which is important to ensure healthy plants development and allows for phytochrome control using different ratios of simultaneous irradiation of red and far red.

Green Spectrum: The amount of green light flux generated by the white LEDs used in GrowRay™ not only increases photosynthetic efficiency by deeper light penetration into the canopy and individual leaves, but is also useful in manipulating plants traits as they counterbalance the effects of blue-light induced cryptochromes while not affecting blue-light generated flux through phototrophins.

Blue Spectrum: The different amounts of blue light emitted by warm-white LEDs is carefully calculated to provide the right balance between wavelengths supplemented by the blue and red LEDs to induce specific desired plant responses at the different developmental stages.