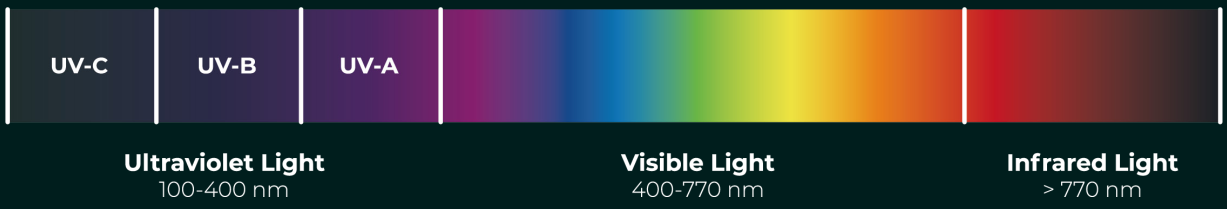
BILBERRY

LIGHT EFFECT ON CANNABIS PLANTS CULTIVATION

1. INTRODUCTION

Commercial cannabis is usually cultivated indoors to ensure fixed conditions. Its production is classified as very energy intensive, as plants require continuous and uniform, high intensity light with air conditioning to create optimal for growth environment. Having this in mind, the choice of lighting is essential, as it determines operating costs, chemical composition of hemp and price of the product.

LEDs have thrust the concept of the spectrum to the forefront of horticultural thought. That's because they can precisely recreate individual colors of sunlight which can be useful in scientific research and, as a result, can translate to a larger scale production - focused on enhancement of desirable traits from commercial crops.



However, not only the intensity of light is important but also quality (spectral distribution) - it is because photosynthesis as well as photomorphogenesis depend on it. Through light spectra plant growth and development can be altered. The spectral information induces a variety of biochemical and morphological responses; although, the result of certain irradiations may be species dependent. Therefore, to engineer a spectrum, which induces specific photobiological response, it is crucial to examine how the chosen cultivar reacts to different colors of light.

Another important factor worth considering when choosing a grow light (especially in greenhouses) is whether it emits any health hazard for people. Some of the wavelengths can cause permanent, although not always immediately noticeable, damage of eyes or skin. A broad spectrum containing all wavelengths is a solution to this problem. It enables better working conditions for people and positively affects early detection of plant abnormalities, pests or nutrient deficiencies.

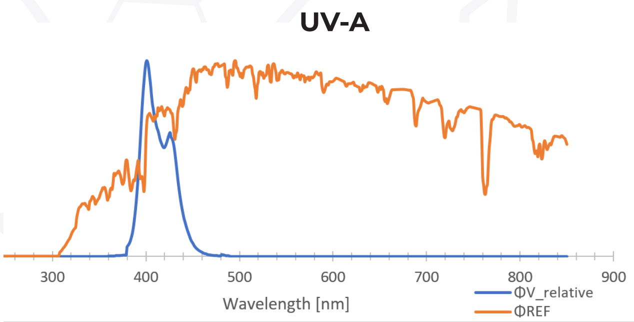
2. INFLUENCE OF LIGHT ON CANNABIS

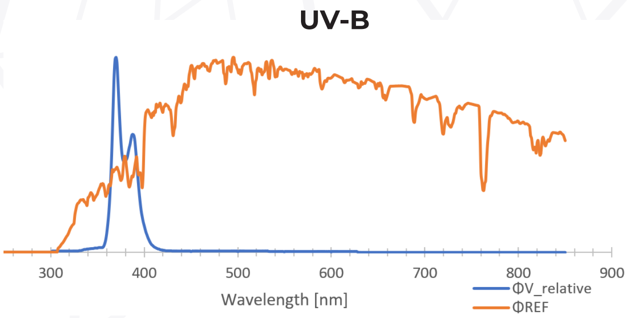
Light has two main functions in plants: assimilative (carbon fixation) and control (activation and regulation of the key processes related to growth). Carbon fixation influences photosynthetic biochemistry and controls leaf anatomy. However, second function stimulates processes such as breaking of seed dormancy, induction of the cotyledon expansion, development of chloroplasts, stem elongation, branch emission, leaf expansion, transition to flowering, fruit setting and seeds production, synthesis of the bioactive compounds.
The color of light affects plants. As they mature and go through the cycle from seedling to adult fully developed plant. The processes such as flowering and fruting require different color spectrum, hence the ideal LED light is different for each stage of growth. High-pressure sodium lamps (HPS) are one of the most commonly used light sources in cannabis cultivation. This type of lighting requires around 1000 W of power, which results in high energy costs. Good substitute resulting this problem is LED lighting. It is not only economically feasible but it also gives the possibility to design the light tailored to plants' needs. The scientific research shows that to obtain optimal photosynthetic assimilation and biomass production it is important to provide plants with proper light spectrum and intensity, temperature, humidity and carbon dioxide content.

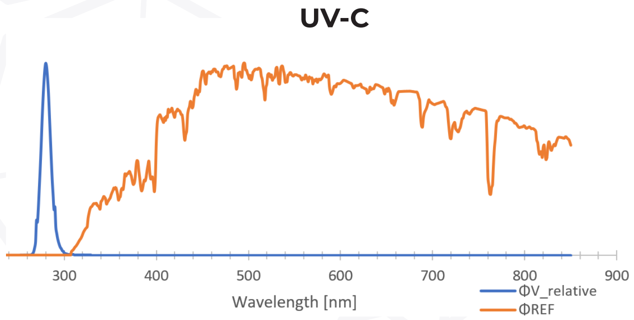
All plants have a light saturation point where the amount of light becomes the limiting factor which impedes efficient photosynthesis. However, very often in cannabis cultivation, inadequate CO_2 supplementation for the given light intensity is the primary limiting factor. The highest photosynthetic efficiency for cannabis is reported to be achieved at 1500 PPFD and 30°C. Surprisingly, it is reduced by nearly 20% when intensity is increased to 2000 PPFD. However, according to the literature, with accurate spectrum, the same results can be obtained at lower intensity. It is because photoreceptors at lower intensity of light are not saturated enough, which in turn results in an increased sensitivity to spectral quality. Therefore, higher cannabinoid concentration may be obtained at lower light intensities which proves that spectral composition plays crucial role in cannabis cultivation.

2.1. UV LIGHT

UV radiation can be differentiated into three types: UV-A (320-400 nm), UV-B (280-320 nm) and UV-C (200-280 nm). Each of these types can affect living organisms differently. They can stimulate and inhibit proper development of the tested plant. The effect depends on the wavelength, intensity and plant species. According to literature data, tolerance to UV radiation is directly connected to their ability to produce secondary metabolites such as flavonoids, which have antioxidant properties and prevent UV light from penetrating plant cells.







Among the cannabis growers there is a growing interest in UV light. Although UV represents a threat to plant integrity in large quantities, smaller quantities of UV have important benefits such as promoting pest resistance, increasing flavonoid accumulation, improving photosynthetic efficiency, and serving as an indicator of direct sunlight and sunflecks. First studies on ultraviolet and cannabis plants indicated, that a small dose of UV-A and UV-B increases the content of Δ9-THC in leaf and floral tissues. However, further research proved that UV-B treatment elicits THC accumulation in both leaves and buds but only in drug-type plants, while in fiber-type plants no change of any cannabinoids concentration was observed. In other studies, it was reported that supplementing with UV-B radiation for 3 h daily increased THC concentrations on C. sativa, whereas supplementing with UV-C radiation influenced resveratrol and piceid levels.

Taking into consideration scientific research low amounts of UV-A and UV-B may be recommended for cannabis cultivation in order to enhance the concentration of THC in drug-type plants, however more examination is needed to specify the appropriate amounts and specific wavelengths. Nevertheless, it is important to remember that too much UV radiation has a negative effect on plant development. Impairment of the photosystem II and I may occur along with a decrease in Rubisco activity, reduction of dry weight and chlorophyll content, induction of stomatal closure, changes in leaf thickness and anatomy of the plant.

2.2. BLUE LIGHT

According to the literature data, blue light affects many aspects of plant growth and development, including inhibition of hypocotyl growth, regulation of flowering, opening of the stomata, the expansion of the leaf area and shoot dry matter. Plants that grow under the spectrum suplemented with blue light are also more compact. This is an advantage comparing to HPS, under which plants are elongated and therefore less capable of supporting large amounts of fruits. When it comes to cannabis cultivation, literature data suggests that blue light is able to increase the concentration of THC, moreover it is suggested that UV-A collaborates with blue light to induce accumulation of cannabigerol in flowers and buds.

2.3. GREEN LIGHT

Green light is most often described as inactive for plant growth and development due to the lack of a photoreceptor dedicated to this wavelength. However, recent meta-analysis suggest that sensitivity to green light should be be divided between shortwave (green) and longwave (yellow) responses, in which green light acts to complement blue light-induced responses and yellow wavelengths antagonize blue light signalling events. Research concerning cannabis indicates that, plants irradiated with spectrum without green light have lower levels of THC than plants cultivated under normal sun light. In other studies it was also mentrioned that a low percentage (≤ 24%) of green light enhanced plant growth, whereas plant growth was inhibited under a higher percentage of green light.

2.4. RED LIGHT AND FAR-RED LIGHT

Red light is photosynthetically active. It influences photomorphogenesis and the synthesis of chlorophyll. It is especially important during the flowering phase for many plants, including cannabis.

Literature data very often indicates that far-red light is photosynthetically inactive and this is why it is excluded from the PAR range (400-700 nm). However, recent studies have returned to the Emerson effect and showed that far-red (700-750 nm) supports photons of shorter wavelengths and therefore the photosynthesic efficiency is increased. Nevertheless, far-red photons alone have only minor positive effect on photosynthesis, but have a large share in the process of photomorphogenesis.

The ratio of red to far-red light (R: FR) has been shown to be particularly important for proper plant growth and development. The low ratio of R:FR results in a number of changes in plant morphology and physiology. The most characteristic feature is the elongation of the hypocotyl, lengthening of the internodes, altered flowering time, and increase in apical dominance. Cannabis plants grown under a spectrum containing too much far-red are extensively elongated and therefore have abnormal morphology.

It was reported that plants grown under sole HPS light may suffer from unbalanced morphology expressed by excessive leaf and stem elongation. This is due to the low R:FR ratio and low blue light emission of the HPS lamp.

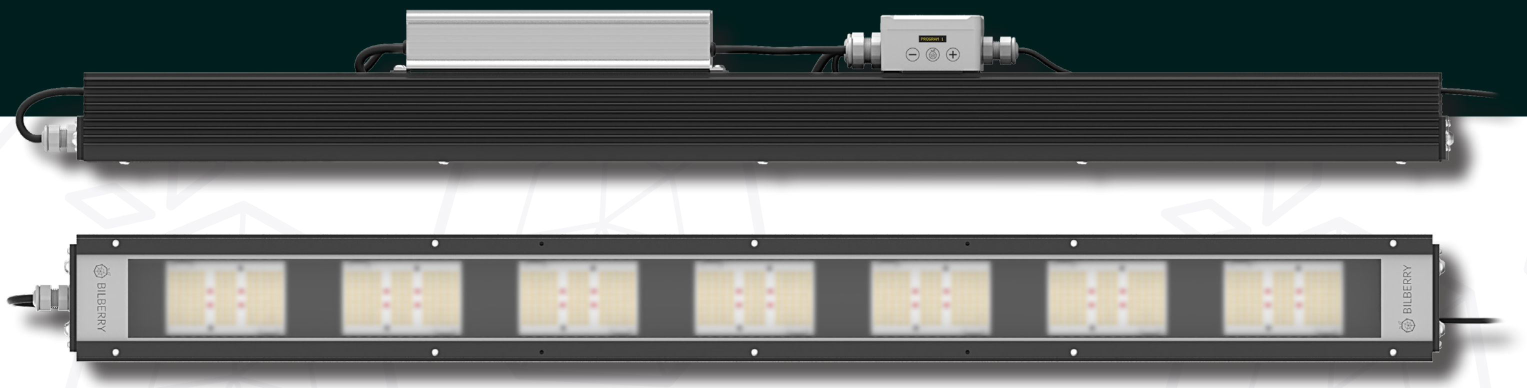
A low R: FR ratio results in:

- Extension of the hypocotyl
- Tether extension
- Change the flowering time
- Increasing apical dominance
- Excessive elongation of leaves and stems

3. BILBERRY'S SOLUTION

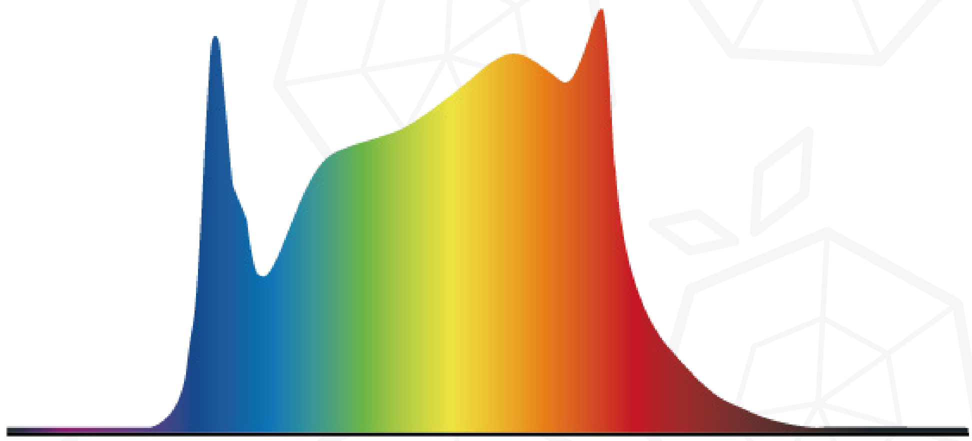
3Style™

In order to fit the very sophisticated needs of cannabis growers, Bilberry has created a fixture with three different spectra - each designed for a different phase of growth in order to maximize results and profits of cannabis cultivation.



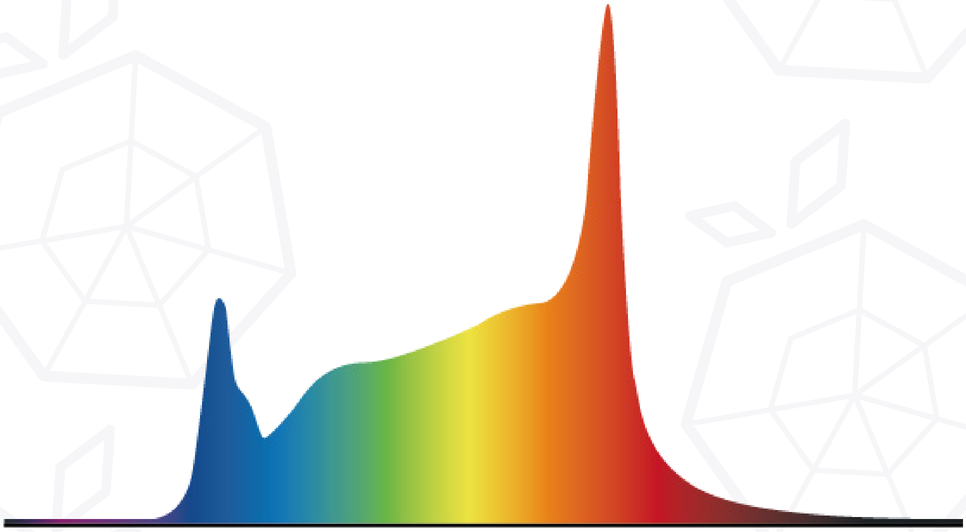
3.1. VEGETATIVE PHASE - GROW

For vegetative phase of growth, white light was especially selected to provide the appropriate proportion of blue to red light resulting with compactivity, correct root development and optimal photosynthetic process without side effects such excessive elongation. It is recommended to use this spectrum throughout the whole vegetative phase even up to sixteen weeks depending on the cultivar.



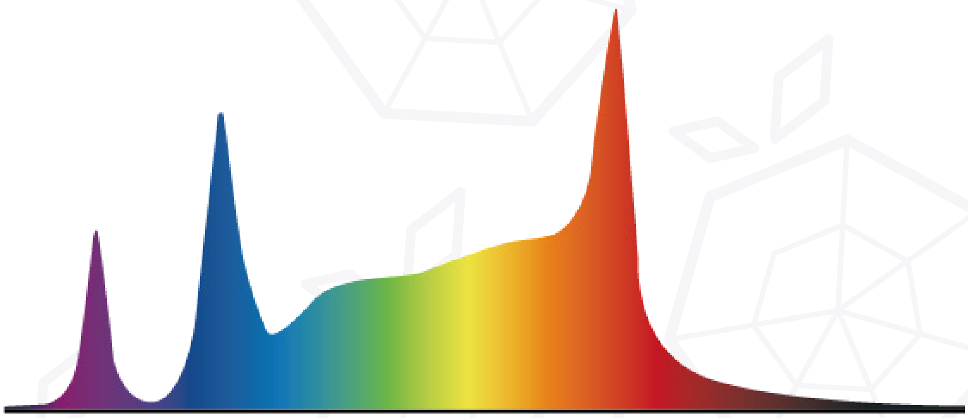
3.2. GENERATIVE PHASE - BLOOM

In order to induce generative phase (flowering), a second spectrum should be applied. Activation and regulation of the key processes related to plant growth are induced by subtle changes in spectrum. Thereby, this spectrum incorporates an increased amount of red light, which accelerates flowering of plants. It is recommended to apply these light conditions at the end of the vegetative phase and throughout the generative phase.



3.3. PRE-HARVEST PHASE - HARVEST

With the use of light, the concentrations of terpenes, tetrahydrocannabinol (THC) or cannabidiol (CBD) could be modified. It was reported that plants grown under supplemental UV radiation had an increased THC concentration. Hence, the third spectrum is complemented with UV light to increase the synthesis of secondary metabolites such as cannabinoids. This spectrum, depending on the individual preferences, can be applied for a few days before harvesting. It is especially important not to utilize this spectrum during vegetative phase as it may create stress conditions for the plants and therefore decrease their quality.



Reminder: UV radiation is highly dangerous for sight and skin, please wear protective clothing while working near this lamp.