

Why red and blue LED grow lights never took off

Anyone who has been growing plants for a while has probably seen a chart showing the absorption profile of chlorophylls A and B, as shown in the image below. From this it seems that most of the light absorbed by plants has a wavelength below 500 nm or above 650nm so it seems incredibly straightforward to hypothesize that plants can be effectively grown just using light in these regions. The commercial answer to this hypothesis came in the form of the red/blue growing LED light, which give the plant energy that it is “best suited” to absorb and avoids “wasting” any energy in the generation of light that will not be absorbed anyway (but just reflected away by the plants). However these grow lights have been an overall failure so far – with the vast majority of the industry now shifting onto full spectrum LED lights – why has this been the case?

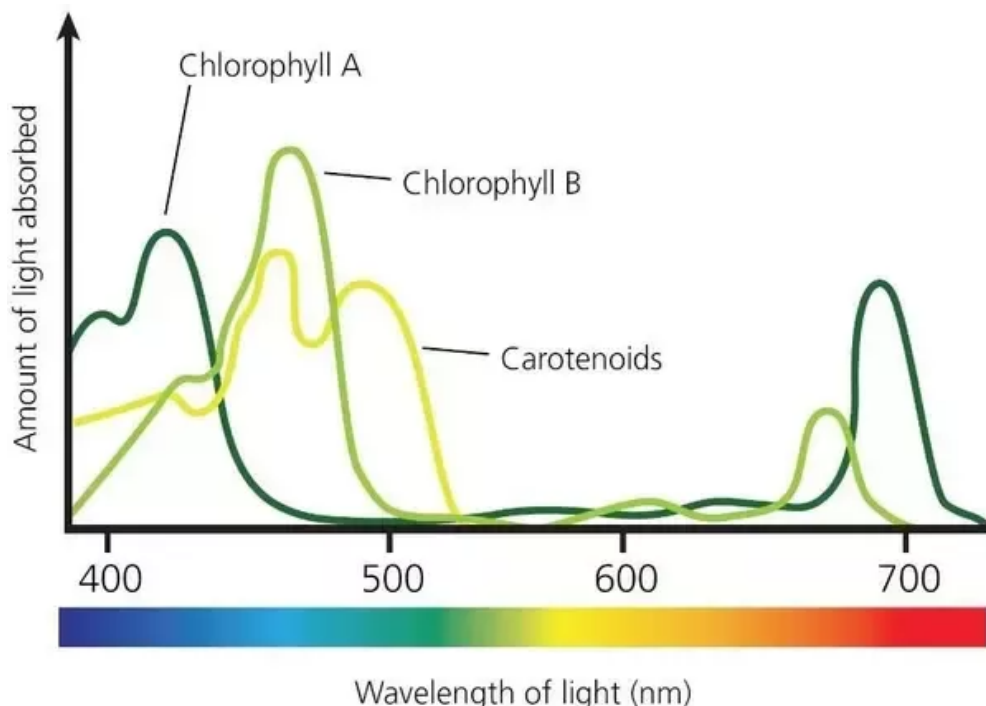


Image showing the absorption spectra of Chlorophyll A, B and carotenoids

When the cost of red/blue lights dropped enough, there was a

significant move to evaluate them in the scientific community to figure out how they affected plant growth. It quickly became clear that plants could be grown with these new lights and that the products could be as healthy as those produced under normal full spectrum lights. However some issues started to become noticeable when these red/blue lights started to move onto larger commercial applications. Although the commercial application of these lights in large fruiting plants is practically non-existent due to the high cost of supplemental lighting, their use was feasible for some small leafy crops – for example lettuce and spinach – which could be grown under high density conditions in urban settings. Their main use however, was in the cannabis growing space, which is one of the only high-cost crops that is grown largely under supplemental lighting when far from the equator.

Most people who tried this soon realized that the growing of plants wasn't equal to that obtained when using fuller spectrum lights, such as HPS or even metal halide lamps, even at equivalent photon flux values. Although scientific publication in cannabis are scarce, this 2016 report ([1](#)) shows that white lights in general did a better job at growing the plants compared to the blue/red lights. Other research ([2](#)) shows that the blue/red lights can also affect the chemical composition of secondary metabolites, which makes the decision to move to red/blue LED grow lights affect the quality of the end-product.

It has also been shown that green light is not entirely unused by plants, but can actually have important functions. This review ([3](#)) goes into many of the important signaling functions of green light and why it can be important for healthy plant growth. Some researchers also started doing experiments with red/blue/green grow lights, showing the positive effects of including some green light in the composition ([4](#)). It has also been shown that other regions of the spectrum, such as the far-red ([5](#)) can also contribute substantially to

photosynthesis and the regulation of plant biological processes. Ultra-violet light can also contribute substantially to the expression of certain molecules in plants. A paper evaluating cannabis under several different light regimes shows how the composition of the light spectrum can manipulate the secondary metabolite makeup of the plants (6).

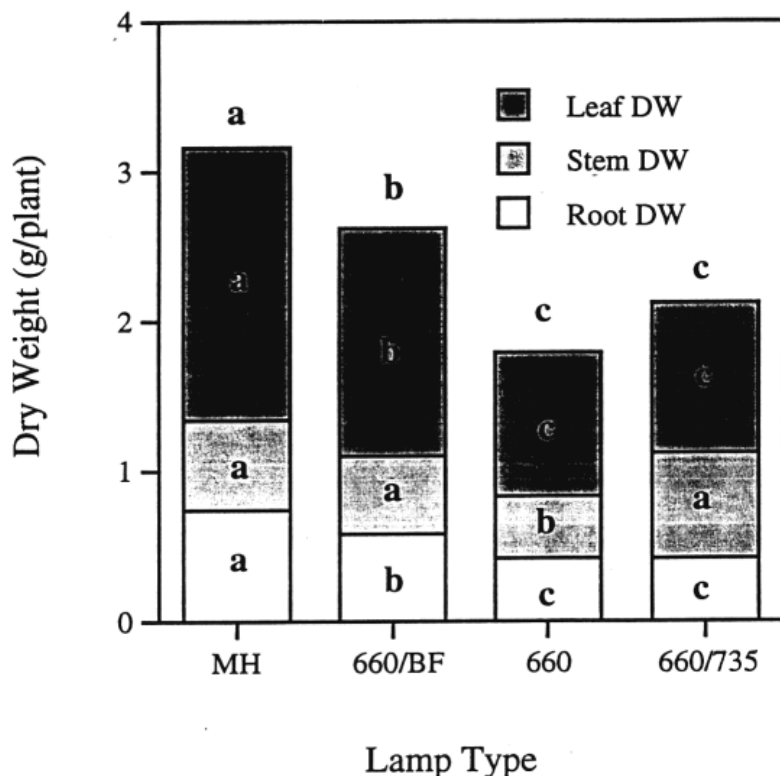


Fig. 2. Dry weight of leaves, stems, and roots of 42-day-old pepper plants grown for 21 days under metal halide (MH) lamps then transplanted under red light-emitting diodes (LEDs) plus blue fluorescent lamps (660/BF), red LEDs (660), and red plus far-red LEDs (660/735), or maintained under MH lamps for an additional 21 days. Similarly shaded portions containing different letters are significantly different based on ANOVA and protected least-squares mean separation tests ($P \leq 0.05$). The letters above the bars indicates the significance for the combined plant dry weight.

Image taken from this study (7) showing the effect of far-red light in the growth of pepper plants.

Finally, the last problem in the grow light phenomenon, especially in the case of plants like cannabis, came from the fact that plants look black under this red/blue light. This meant that growers were completely unaware of any potential problems that developed, as the plants were virtually invisible to them through their entire lifetimes. This was one

of the main reasons why these lights were never widely adopted, as they made the diagnosing of nutrient issues and insect issues – which are relatively easy to diagnose under full spectrum lights for an experienced grower – almost impossible to do with these red/blue growing panels. In practice a large commercial operation relies heavily on the experience and on-going evaluation of the crop by the on-site personnel and failure to have this useful check in the process is a recipe for disaster.

The LED industry learned from these problems and has since gone into the development of full spectrum high efficiency growing panels for the hydroponic industry. These will certainly become the future and standard in the in-door hydroponic industry, especially if prices continue to come down as a consequence of mass adoption. Having full spectrum lights that are way more power efficient than HPS and MH lamps will offer growers the chance to save a lot on costs while maintaining, or even improving, the quality and yield of their crops.

DIY Warm white LED lamp PAR measurements, not so exciting after all!

If you read my last few posts about DIY LED lamps built using 150W warm white LED cobs (which do not require an independent driver) you might have been excited by some of my claims. I previously stated that you could probably get around a 1000W HPS equivalent using just two of these lamps, which meant an energy saving of around 60% relative to the HPS equivalent.

However to really verify these claims I wanted to get new PAR and lux meters to perform proper PAR and lux measurements. The results my friends, are disappointing.

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|----|-----|----|
| 42 | 56 | 20 |
| 53 | 220 | 76 |
| 43 | 62 | 24 |

Previously I thought that these lamps were close to half of an HPS equivalent based on initial lux measurements. At the same distances, directly below the lamp, I could get around half the lux equivalent of your average HPS lamp, I thought from the warmer spectra of these white warm cobs that the PAR contribution would be significantly higher than that of a regular HPS but it seems that – due to the inefficient use of a white phosphor to produce the spectra – basically the PAR efficiency is equal to that of an HPS lamp.

The PAR (Photo-synthetically Active Radiation) basically measures the number of photons that can be used in photosynthesis that you get per square meter per second off a given light source. I will write a more in-depth post about PAR in the future, but it basically tells you the plant-usable photon flux you get. It is therefore measured in $\mu\text{mol}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$.



I performed classic PAR measurements with a 150W lamp 15 inches above a target center with measuring points around a 4 square feet area (to compare with the variety of HPS measurements you can find [here](#)). The results, in the first image in this post, show you the map of PAR values across the 2 feet by 2 feet area. This shows that the lamp is basically giving you $1466 \text{ umol*s}^{-1}\text{*m}^{-2}$ per 1000W at its highest point, which is below the PAR/watt of even the poorest HPS models. With this lamp model using 150W cobs you will therefore need at least 7 lamps to reach the same equivalent of a 1000W HPS in terms of actual photo-synthetically active radiation.

Not only that but without any focusing or dispersing elements the PAR decay as a function of light distance is much more dramatic than for regular, reflector mounted HPS lights. **With all these information it now seems clear that these warm white light LED cobs are NOT a good HPS replacement.**

However the idea of the zip tie lamp is not dead! I found out that there are actually “full spectrum” LED cobs that are specifically designed to be grow lights (so basically a combinations of red and blue LED lights). These cobs come in 20, 30 and 50W formats and they should have a much more favorable PAR than the 150W warm white LED cobs. I have now ordered some of these cobs ([here](#)) to rebuild my zip tie lamp

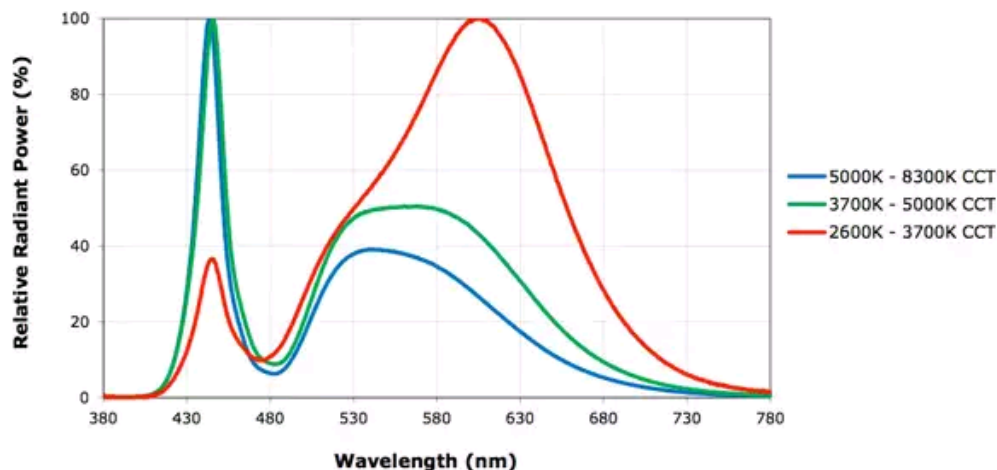
and see if I can indeed get a much better PAR/watt and watt/dollar compared with normal HPS lights.

Building your own DIY high power LED lamp: Part One

It is no mystery that LED technology has evolved greatly during the past several years. We are now up to the point where anyone can buy LED lamps to replace HPS fixtures, with full spectrum LED configurations that have showed to be just as good – or sometimes even better – at growing crops (see [here](#) for a post about LED lights Vs HPS). However these lamps are often very expensive – most commonly around thousands of dollars to adequately replace a 1000W HPS. Within these series of posts I am going to talk about how you can build your own LED lighting to replace HPS lights for pennies on the dollar compared to commercial LED fixtures.

WARNING: Mains voltages (110-220V) can be extremely dangerous. Please make sure that you know what you're doing if you're going to follow these instructions. All of this information is provided "as-is" with educational purposes only. Make sure you follow all safety precautions when working on mains electricity.

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There are several ways in which you could build your own LED lamps. This usually involves building an aluminium case with fans, putting an LED driver inside and then using that driver to power rows of different light emitting diodes. A driver is basically a transformer not unlike a computer PSU that takes voltage from the mains and dials it back down to a lower voltage that you can use across a row of diodes. Most commonly commercial lamps use combinations of 3W diodes with narrow focusing elements with sometimes higher wattage elements with wider focusing elements. Building a configuration like this can be done but it is a laborious that we can avoid using some of the latest advances in LED technology.

To make a simple high power LED lamp we should absolutely forget about putting together LED elements of different colors. This involves a lot of wiring and makes the lamp fundamentally more expensive. To replace them we can use white diodes instead which although far less efficient – as they are basically blue diodes whose light is absorbed and re-emitted by a phosphor – can give us all the different colors we need in the proportions we need them. The image above shows you the spectrum of different white diodes, as you can see we don't want the 5000-8000K or 3700-5000K LEDs – which emit a lot of blue light we don't need – but we need the much “warmer” 2600-3700K diodes which produce a lot of light in the red

region of the spectra, with enough blue to provide us with close to a 1:3 ratio. Although this light spectra is still not ideal compared to what plants absorb it will easily be able to replace a 1000W HPS.

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To make things very simple and avoid using a separate driver we can use 150W LED cobs that include their own driver and are fed directly with 120/240V electricity (like the ones [here](#)). As I mentioned we want the lower temperature spectra white diodes so go for the “Warm white” and make sure the temperature description says it is at least 3200K or lower (if you’re looking at another source). The publication above contains 150W cobs that can do 2500-3200K so they can be considered ideal for this application. For every 150W cob you install you should also install a 2A AC fuse for that cob only to ensure that if anything bad happens the power will be cut almost instantly. *Since these cobs are wired directly to mains electricity you should be specially careful with having proper safety precautions (proper soldering of the wires, solders protected with isolating material (like silicon) fuses for each cob, etc).*

Of course the cobs are only half the setup. We need to place these cobs on top of an appropriate heatsink and then also ensure we have fans for it. You can buy a properly sized aluminium heat sink [here](#). Since cobs measure 16×40 we can comfortably glue two cobs to the bottom of a heat sink of profile A (146x22mm) with a length of 400mm. To glue the cobs to the heatsink you should use proper arctic silver thermal adhesive (you can find it [here](#)). For fans you can place 2 12cm Fans on top of the above. There are several fans that work with 120-240AC that you can use, for example [these fans](#) work with 120V. This setup will give us a 300W LED lamp, with 2 fans that should be able to keep the heatsink temperatures in check. All of this for a total of around 83 USD, let's call it 100 USD after adding fuses, cable and other parts you might require.

The above lamp will not replace a 1000W HPS on its own, for this you will need at least 4 cobs – meaning two of the above lamps – which should give you 600W of LED power that should be close to the PAR of a 1000W HPS light. This for the cost of only 200 USD (far less than the commercial LED replacement lights). I am in the process of making my own so I will be able to give you some additional details as soon as I get the parts and finish building my own setup. In part No.2 of this series of posts I'll show you the results of my work and what it does in terms of photon flux and PAR.