

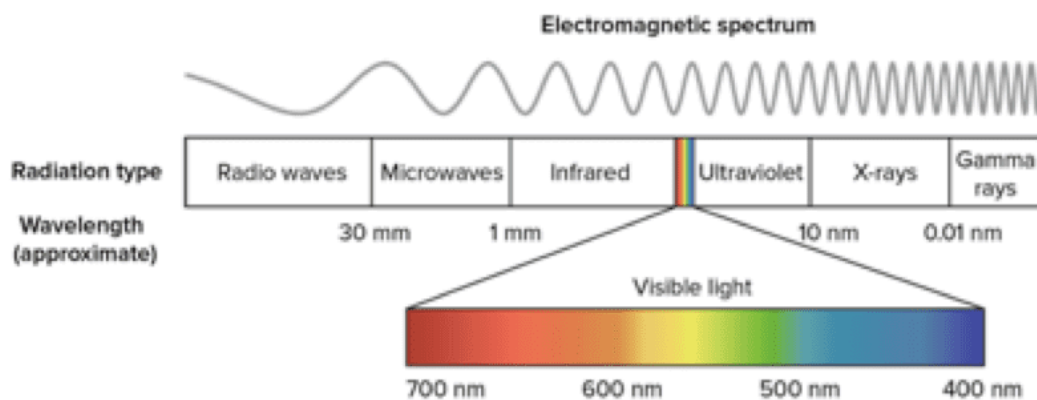
# LED grow lights for Vertical Farming - Understanding PAR, PPF, and PPFD

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Artificial lights have long been used in agriculture to supplement the natural light and increase crop yield. The scenarios where external lighting may be of use may include growing in areas with shorter day-light duration, cold climatic zones, growing indoors, or growing in Vertical farm, etc.

There are different kind of artificial lights that can be used for supplementing growth like incandescent bulbs, fluorescent lights, metal halides, high-pressure sodium halides, LED lights, etc. The scope of this primer is limited to LED based grow lights used in Vertical Farms.

## Basic Concepts



## What is light?

Light is the part of the electromagnetic spectrum that is visible to human eyes. This will range from approx. 400 nm to 700 nm.

### ***How is it measured?***

The standard unit of measuring light is lumens (or foot-candles or lux). This unit measures the brightness of light as measured by human eyes. This measure will have the highest reading in the yellow-green spectrum, and lowest on either end (the red and the blue spectrum.)

### ***Do plants see the light in the same way as humans do?***

Plants do not see (read use) the light the same way as humans do. Different frequencies of lights show different impact on different biochemical processes within the plants. As such it is not ideal to use the measures (like lumens) developed for human eyes to measure and understand the impact of light on plants.

### ***How do plants use light?***

Different wavelengths of light pack varying amount of energies in them. This energy is carried by photons. When the photons fall on plant's surface, they get absorbed by specific pigments (ex chlorophyll a, chlorophyll b, carotenoids, etc.) within the plants and the energy thus released helps in carrying out the process of photosynthesis. As such, for plants, instead of measuring how bright a light is (lumens), it is more relevant to measure how many photons are being emitted by the light.

## Units of Measuring Light for Plants

### PAR

Earlier, it was believed\* that only the lights between 400nm to 700nm (approx. same as the visible spectrum) impact the rate of photosynthesis in plants. The wavelengths in this range are thus deemed to be Photosynthetically active.

PAR (Photosynthetic Active Radiation) is the term used to denote wavelengths between 400nm and 700nm. PAR measures all these wavelengths equally. Unlike a lumen scale which will show a higher peak for the yellow-green region, a PAR scale will show each wavelength to be of the same height in a uniform light.

## PPF

Photosynthetic Photon Flux measures the total amount of PAR produced by a lighting system each second. In layman terms, it measures the number of photons (within 400nm to 700nm range) that are being emitted from a light source per second.

## PPFD\*\*

PPFD or PPF Density measures the amount of PPF that falls on a plant's surface per second.

While evaluating two grow lights, the one with higher PPFD rating would be better than the one with lower rating.

\*It is now known that even UV and IR wavelengths impact the process of photosynthesis.

\*\*PPFD reading does not include PPF produced by IR or UV wavelengths.

## Spectrum

Going by above understanding, one may ask, is PPFD the holy grail of plant lighting? Is it the only parameter one should consider while evaluating lights?

The answer would be a resounding NO!

Using the PPFD measure, we can find out how many photons are reaching the plant surface. Yet, by using PPFD alone, we cannot figure out the distribution of these photons. As stated earlier, different photons carry a different amount of energy in them. Photons of a few specific wavelengths have a greater impact on the process of photosynthesis than the photons of other wavelengths.

What that means is, if somehow we can control the wavelength of photons coming from a light source, we can impact the rate of photosynthesis as well. This ability comes through using LED diodes that emit photons of a particular wavelength. The distribution of different diodes in a light source defines the Spectrum of the light.

Along with PPFD, the Spectrum is the other important parameter that one should consider while procuring grow lights. In the next article in this series, we will take a closer look at the Spectrum. Till then,

Happy Growing!