# What's The Scoop on Grow Lights and Colors?

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If you've seen blue and red LED grow lights online and at the big box retailers, you may be asking yourself what's special about blue and red lights. What effect do they have on plant growth? NASA, the National Aeronautics and Space Administration, has been asking the same question and funding research because of their interest in growing food in space and on Mars. With the boom in greenhouse and vertical gardening, commercial agriculture is also exploring innovations in lighting. These efforts have two goals: producing the healthiest plants and doing so in the most economical way.

Now thanks to decades of research including Utah State University's Crop Physiology Laboratory, led by director Bruce Bugbee, Ph.D., research is transforming the scientific understanding of light and its effect on plant physiology. And it's providing some surprising insights into the visible as well as invisible spectrum of light.

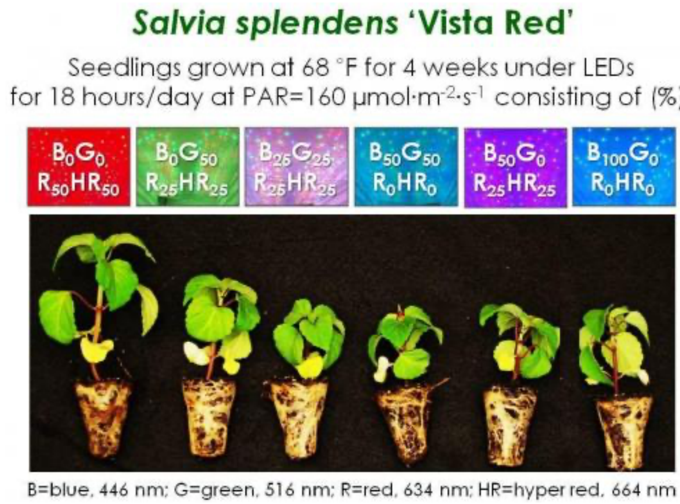

photo: Michigan State University

The blue spectrum, defined as light falling between 400 and 500 nanometers (nm), plays a major role in shaping plants. It limits stem elongation, so you grow very compact plants with thicker, darker colored leaves. Unfortunately, it also limits leaf expansion. Studies comparing plants raised with 20 percent blue light vs. 5 percent blue light typically result in plants one-third shorter, depending on the specie of plant studied.

Red light, which falls between 600 and 700 nm, is extremely efficient at converting electricity into photosynthetic photons. Thus, you get more photosynthesis for the dollar spent on electricity. Studies show they generate about 15 percent more photons than blue LEDs. The red light spectrum, along with its far-red sidekick, also helps to stimulate flowering.

The green spectrum, ranging from 400 to 500 nanometers, is far more important than once thought. It is also very efficient for photosynthesis, with about 10 times the brightness of red or blue light. Green's special power, however, is in penetrating the plant canopy to reach down into the lower leaves of the plant, thus producing a healthier plant overall. It also facilitates human vision, so we can see the health of the plants, including subtle nutritional disorders, insects or disease.

But that's not all. It turns out that plants use a far wider range of the light spectrum than humans can see. Infra-red photons are tremendously effective in enhancing cell division, resulting in taller plants and larger leaves. This is especially beneficial for leafy green plants, like lettuce, spinach and kale. It turns out that blue and far-red photons are the "designer" wave lengths that affect plant shape. They can be mixed and matched in LED light fixtures depending on the intended crop to shrink or swell stems to produce taller or fuller, more compact plants.


photo: National Academic Press

*Lights used by commercial growers*

New to scientists' understanding of light effect on plants is that blue and red lights are absorbed at or just below the leaf surface, while green and far-red penetrate deep into the leaf and down into leaves below. This is another reason to be sure to include green in the mix.

But that's still not all. Ultraviolet A (UVA) light, the 315 to 400 nm range, plays a huge role in growing tasty and nutritious food. Plants produce anthocyanins, flavanols and other compounds as sunscreen to protect themselves from the UV rays. These compounds are the deep reds, blues and purples found in deeply colored leafy greens, vegetables, berries and other fruits that provide some of our most densely nutritious and delicious food. The more UV, the more intense the result. So, allow enough space between plants for the light to reach as many leaves as possible.

Bugbee notes that in the early days of LEDs for plant growth, it was thought that green wasn't very efficient. Lights were produced with mostly blue and red LEDs, resulting in lots of problems. Today manufacturers are putting a lot more white LEDs in their fixtures to get the right mix of the green light spectrum. A high-end option is to add 50 percent infra-red LEDs to fixtures. Infra-red LEDs are more expensive to produce than the visible range of blue, green and red, however. Keep in mind that plant species respond slightly differently to each of the spectrums of light.

LED Efficacy and Cost

In addition to the effect on plant growth and nutrient density, the next most important consideration in LED lighting is photons generated per unit of energy input. This is measured in micromoles per Joule. While the terminology and equations are complicated, the concept is straightforward: How much useful energy (photons) plants can get compared to the amount of electrical energy needed to produce that result. When you compare the ratios for each of the LED colors, there are clear winners:

| | Efficacy | Relative Price |
|---|---|---|
| Far-red | 4.0 | 10x |
| Red | 3.8 | 5x |
| Blue | 3.3 | 5x |
| Cool White | 3.0 | 1x |

Because the cool whites are mass produced for human use, they cost a lot less to buy than other LED colors. This offsets the slightly lower efficacy.

Flowering

Another effect that should be considered in the mix of LEDs for plant growth is the effect of red and far-red radiation on flowering. Plants are very sensitive to even low intensities of red light. Even a tiny amount of red light at night can inhibit the flowering of some short-day plants. Conversely, it promotes flowering in long-day plants. While white light includes red, the addition of far-red LEDs to the fixture can help to promote flowering, including buds on fruits and vegetables, such as tomatoes, beans and squash, to name a few.

The Bottom Line
It turns out that Mother Nature is perfect once more. Plants have evolved for eons using the full spectrum of light generated by our sun. Many gardeners start seeds inside under grow lights then move the seedings outside in natural sunlight during the warm parts of the day to absorb the full spectrum of light available from the sun. Thus, it’s best to use grow lights that copy this formula as closely as possible. Depending on your budget and goals, this may also mean including some UVA and far-red as well.

**Resources**


- Toward an Optimal Spectral Quality for Plant Growth and Development, Bruce Bugbee, Utah State University,
- Grow lighting Masterclass with Dr Bruce Bugbee — Grow Light Spectrum Discussion, Bruce Bugbee, Utah State University
- Far-red photons have equivalent efficiency to traditional photosynthetic photons: implications for re-defining photosynthetically active radiation, Plant, Cell and Environment, Shuyang Zhen and Bruce Bugbee, Utah State University
- Substituting far-red for traditionally defined photosynthetic photons results in equal canopy quantum yield for CO2 fixation and increased photon capture during long-term studies: Implications for re-defining PAR, Frontiers in Plant Science, Shuyang Zhen and Bruce Bugbee, Utah State University
- Effects of Blue Light on Plants, Erik Runkle, technically speaking, Michigan State University
- Do changes in light direction affect absorption profiles in leaves? Functional Plant Biology, Craig R. Brodersen and Thomas C. Vogelmann, 2010,37:403-412
- From physics to fixtures to food: Potential efficacy of LEDs, Nature: Horticulture Research, Paul Kusuma, P. Morgan Pattison and Bruce Bugbee
- Red Light and Plant Growth, Erik Runkle, Michigan State University
- Sun Graph for Fairfax, VA, Time and Date AS, Norway