Plants, Light, and LEDs: Putting It All Together

Part 2 – Plants and Light
The art of harvesting sunlight

Topics

- How do plants catch light, and what do they do with it?
- Why do some colors of light work better than others for growing plants?
- How many different colors of light do plants need?
- How bright does a light need to be to make plants grow?

How do plants catch light, and what do they do with it?

Light provides the energy plants use to live and grow. They have a unique ability to catch light and store its energy in chemicals like sugar and starch, which are then used to power the plant's cells. The light energy stored in plants not only allows the plants to grow, but also supplies the energy needed by every other living organism on earth, either directly (if you eat plants) or indirectly (if you eat something that ate plants). If it wasn't for plants we wouldn't be here.

But how do plants catch light? To catch light plants use special chemicals called pigments, which are nothing more than substances that catch light. Pigments are all around us, and are the reason that every object has a particular color. And there are pigments in our eyes that allow us to see these colors, too.

Everyone is familiar with the idea of adding pigments to paint to create different paint colors. So how does something that captures light make your paint look blue? When you add a blue pigment to paint, you're really adding a chemical that catches all the other colors of light except blue. So the blue light bounces off of the paint, making it look blue to us.

Plant pigments do the same thing. The best known plant pigment is chlorophyll, the pigment used in photosynthesis, the process that catches light energy and stores it in sugar and starch. Chlorophyll is the pigment that makes plants look green. Why? Because chlorophyll is very good at catching

red and blue light, but terrible at catching green light. The green light bounces off the plant's leaves, making them look green to us.

There are other pigments in plants that catch light and use it to regulate plant growth. While the plant's chlorophyll is busy catching as much energy as possible from the light, the other pigments are figuring out things like whether the plant should grow short and compact or tall and spindly, or whether it's time to make flowers. Just like the pigments in our eyes give us a picture of the world, plant pigments tell them about their environment and allow them to adapt to it.

Why do some colors of light work better than others for growing plants?

As we noted earlier, plants use pigments to catch light. Every pigment has something called an absorption curve that shows how well that pigment is able to catch light of different colors. Each pigment has one or more absorption peaks, which show the colors of light which that particular pigment absorbs best. That doesn't mean it can't absorb other colors of light, just that it doesn't absorb them as well.

We've also learned that chlorophyll is good at absorbing red and blue light, but not so good at absorbing green light. Since chlorophyll is used by plants during photosynthesis, which is a major plant process, we know that if we shine red and blue light on a plant it will drive the photosynthetic engine better than an equivalent amount of green light would.

For many plants it seems that they just look green, and we don't see any other colors that might hint at the existence of other pigments. In the fall, though, the spectacular color show put on by deciduous trees shows us some of the other pigments within the leaves of trees. These other pigment colors are masked by the green of chlorophyll during the growing season. Then when autumn comes and the leaves lose their chlorophyll, the hidden pigment colors are suddenly revealed. Since these autumn colors are not green, but are instead yellows, purples and reds, we also know these other pigments are absorbing different colors of light than chlorophyll.

Sunlight contains roughly the same amount of each color of light that plants use, so when you grow plants outdoors you don't have to worry about whether or not the light is good for growing plants. Nothing works better than sunlight for growing plants. But when you're considering using a man-made light source (i.e. a grow lamp) to grow your plants it's important to know whether or not that lamp will provide an appropriate mix of light colors for growing plants.

How many different colors of light do plants need?

That's a good question, and one for which nobody has a complete answer. We can identify the pigments contained in plant tissues, and we can figure out the absorption curve for each of those pigments. After that, though, things start to get a little vague, and there are many opinions about what colors of light plants require, but not many definitive answers.

The primary pigment-driven process in plants, and the one that's been studied the most and is best understood, is photosynthesis. There are several types of chlorophyll in plants, and they all have absorption peaks in the red and blue portions of the light spectrum. Because of this many early studies of how different light affects plant growth focused on the use of red and blue light. Many people point to early NASA studies involving the use of red and blue light for plant growing as proof that those are the only light colors needed to grow beautiful, healthy plants.

Unfortunately the NASA studies didn't really use only red and blue light sources. They used red LEDs, which were readily available at the time,

plus a small amount of fluorescent lighting to provide the blue component. Why? Because blue LEDs hadn't yet been invented. The true result of the early NASA experiments was that using red LEDs along with fluorescent lighting, which contains many different colors of light, provided reasonable plant growth, but not that plants will grow well using only red and blue light.

In our own experience we have found that while plants will indeed grow using nothing more than red and blue light sources, they don't turn out the same as plants grown in full sun. Their coloring may be different, or their flowers may not have any perfume. In fact, they may not bloom at all. And vegetables and herbs may have either a strange taste or not have any flavor at all.

The fact is that plants contain a broad array of pigments, and not all plants contain the same pigments, yet they are all there for a purpose. In many cases we don't yet understand what the purpose of one or more pigments is, but they all have some purpose. A man-made light generator that provides all of the colors readily absorbed by the pigments found in plants will likely perform better than grow lights containing very few light colors.

How bright does a light need to be to make plants grow?

This is another good question that is difficult to answer. There are two basic problems in determining how bright a light needs to be for growing plants.

First, what does "bright" mean? Something that appears to be bright when you look at it? That's obviously not a very scientific way to measure a light source, even though it seems like a light that looks bright should work better than one that doesn't. But because of the way human vision works, it's not necessarily true that the lamp that appears brighter will grow a better plant. To the human eye, colors that plants don't use very well, such as green and yellow, look much brighter than colors like red and blue that plants use efficiently. Thus it's entirely possible to have a very bright looking lamp that produces very little light that plants prefer, while a second lamp with an excellent mix of plant-growing light colors might seem relatively dim.

The human eye can't be relied on to determine which man-made light generator is the best choice for growing plants.

Second, until very recently it wasn't possible to create a man-made light generator tailored specifically to the needs of plants. There was sunlight, which contains all colors of light in roughly equal proportion, and there were plant growing lamps made by slightly modifying existing lamps that were initially intended to light rooms. Because these early, man-made grow lamps were based on ordinary room lamps, they produced many colors of light that work well for lighting rooms for people but those same light colors aren't particularly useful for growing plants.

There have been many studies to determine the amount of sunlight that's needed to grow plants. Since sunlight contains all colors of light in nearly equal proportion, though, and plants don't use all colors of light equally well, these studies don't tell you how well any of the man-made light generators will grow plants. All man-made light generators produce only a very few colors compared to sunlight, and the colors aren't produced in equal proportions.

The fact is it simply isn't possible to compare an amount of sunlight that's known to grow plants well to the measurements taken of man-made light generators. It also isn't possible to compare the light output of one man-made light generator to another, because no two types of lamps create the same light colors in the same proportion.

We'll look at the issues surrounding comparisons of sunlight to various man-made light generators and their ability to grow plants in Part 3. For now, we know that plants catch light using pigments, and that there are many different pigments in plants. It's also clear that each pigment has its own absorption peaks, and that a man-made light generator that only creates red and blue light isn't fully addressing the needs of plants.

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