Growing Seedlings Under Lights

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Many farmers and homeowners grow their own seedlings for transplant. Doing this indoors can save the cost of buying, heating and maintaining a greenhouse. Doing it indoors, however, also requires the use of artificial lights. Knowing how to use artificial lighting to grow seedlings can be challenging. This fact sheet will address some of the questions and challenges about growing seedlings with artificial light while helping to understand light and how it is perceived and used by a plant.

First, one quick bit of science: light acts both like particles and like waves. What this means for us is that:

1. We can count the particles (called photons), and

2. We can measure the waves. We measure them by how long they are (called wavelength). We see the different visible wavelengths as different colors, and we see all the visible wavelengths mixed together as white.

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Did You Know?

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Light Requirements For Plants

A plant's need for light can be thought of like a bucket being filled with water, where the different light sources are different hoses. For optimum growth, a plant needs to have its light bucket filled every day.

Shade tolerant plants, like ferns, have smaller buckets. Sun loving plants, like tomatoes, have bigger buckets. The same plant can have different light buckets at different times of its life. For example, a growing pepper seedling has a smaller light bucket than a pepper plant, which is ripening fruit.

A plant which day after day doesn't get its bucket filled can't grow properly. In seedlings, this looks like stretched, thin plants with lots of space between the leaves. How much light a plant receives over the course of a day is called its "Daily Light Integral" (DLI). We measure DLI as the number of photons that hit a square meter over the course of the day, and we count the photons in "moles"[1].

1 "A mole" is simply a number, like "a dozen," except much, much bigger. A mole is a six with 23 zeros. Imagine dumping out a dozen ping pong balls and what that would look like. If you dumped out a mole of ping pong balls, it would cover the Earth more than twice the depth of Mt. Everest!

In this analogy, different light sources (whether the sun or lamps) put out different quantities of light. A tomato seedling may have its light bucket filled for the day in just five hours in full sun, whereas the same plant may need 22 hours of a fluorescent light, just because there are so many more photons coming out of the sun every second than out of the fluorescent light.

A source can give too much light every second, too, like trying to fill the bucket in a few seconds with a fire hose; the plant can't use that much water at once and most of it is wasted, perhaps even damaging the plant. How much light the light source gives every second is called the light Intensity. We measure Intensity as the number of photons that hit a square meter every second, and we count the photons in moles.

To take our bucket analogy further, imagine that there are things coming out of the "hose" (light source) other than water, say, mud particles. The plant can only use the water and not the mud, so if the hose gives a lot of mud it needs to run longer to put out the same amount of water as one that has less mud.

Plants use some wavelengths of light very well, other wavelengths not so well, and other wavelengths not at all. If a light source has mostly wavelengths that a plant can use well, it will require less time to fill the plant's "light bucket" than a light source of the same intensity with a lot of wavelengths the plant can't use.

How much of the light in the wavelengths that is useful to plants is called the light Quality. The Intensity of a light, within the wavelengths that a plant can use, is called "Photosynthetically Active Radiation" (PAR) (also known as "Photosynthetic Photon Flux Density" or PPFD) and it's what we measure with a horticultural light meter.

For the last thing we'll add to our bucket analogy (and this one is a bit harder to imagine), imagine that the bucket could tell how long the hose was running, and use that information to determine what time of year it was. If the hose was running for 15 hours a day in New Hampshire, the bucket assumes it is in June. When the hose only runs for nine hours a day, the bucket assumes it is in December. This is completely separate concept from how long it takes to fill the bucket; it's all about what time of year it is.

A plant could have a very poor quality, low intensity lamp shining on it for 15 hours per day and still not have enough DLI, despite "thinking" that it was June. Anyone who has kept a poinsettia in a living room has seen this: running a television on a poinsettia at night in October is enough light to make the poinsettia "think" it is June and refuse to flower, even though there is not enough light coming from the television to grow a healthy poinsettia.

How long the plant is being lit between dark periods is called Daylength. Daylength is used by the plant to tell what time of year it is, and mostly relates to flowering and fruiting responses. It isn't terribly important for the production of most seedlings, except for things that need to be kept in a growing phase before they enter a flowering phase

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(like begonia, poinsettia and cannabis).

When Extension gets questions about light from people growing seedlings indoors, often the question is about Quality ("should I use a grow light instead of a shop light?") when the focus should really be on quantity, or DLI.   Most seedlings can be grown to transplant stage with high quality T8 four- bulb fluorescent "shop lights," but the lamps need to be kept close to the tops of the seedlings (less than one foot away) and these lights need to be run for 22 hours to get the DLI ideal for seedling growth of sun-loving plants.

A fancy purple horticultural LED (which is actually a combination of red and blue wavelengths) may only need to run for 10 hours to accomplish the same level of growth, while a cheap purple LED may need to run for 34 hours per day, which is impossible!

It's important to know that the Intensity of light coming from a light source decreases rapidly as the light source gets further away. For example, to reach the DLI requirements for optimal seedling growth, one of the commercially available LED "light bars" I have tested would require eight hours per day if mounted 8" above the crop, but would require 16 hours per day if mounted 20" above the crop.

Keeping the lights close to the plants and raising the lights as the plants grow is a technique to get the most light out of our fixtures. You can purchase adjustable light hangers designed for this purpose. Keep in mind that most fluorescent light fixtures have a "ballast" at some location along their length, and that this ballast often produces much more heat than the rest of the fixture. The plants under the ballast may require water much more frequently or may even burn from the higher temperatures.

How can a grower know how much light is being provided to his or her seedlings, and whether that is enough? With a horticultural light meter (one that measures PAR), we can measure the intensity of the lights at the crop height and calculate run time based on ideal DLI for the plants being grown.

Without a PAR meter, we need to let the plants tell us if they are receiving enough light. When a seed germinates in low light conditions, it "thinks" is it beneath a canopy of competing leaves, and it will elongate its stem in an attempt to "stretch" above the canopy to reach the sun. Once a stem is stretched, adding light will not shrink it back down, but adding light may prevent further stretch. If more light is needed, your options are to: buy a lamp with better Quality, buy a lamp with more Intensity, increase the number of lamps over the crop, lower the lamp closer to the crop and/ or increase the amount of time the lamp runs each day.

Some suggested run times for different lamp types are listed below. These are just a rough guideline; without measuring your actual light output at the crop level, we can't get an accurate estimate of DLI. For the sake of this table, I am assuming the

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following: seedlings want 12 moles of light per square meter per day (this is how we measure DLI), the lamp is one foot above the crop, the lamp is the only source of light on the crop.

Lamp	run time (hours per day)
(2) T8 fluorescents 48" 32W 5000K	48
(4) T8 fluorescents 48" 32W 5000K	22
(6) T8 fluorescents 48" 32W 5000K	16
(2) T5 fluorescents 48" 54W 5000K	26
(4) T5 fluorescents 48" 54W 5000K	13
(6) T5 fluorescents 48" 54W 5000K	9
(2) T8 LED tube 48" 32W focused spectrum	56
(4) T8 LED tube 48" 32W focused spectrum	28
(6) T8 LED tube 48" 32W focused spectrum	19
LED Grow lights	extremely variable

The above discussion has been assuming that the light source in question is the only light being provided, say in a grow chamber, closet or other indoor space. People who are growing in a greenhouse have another factor to consider, however: how much of the plant's needed light is already coming from the sun? Most of the crops grown for transplant in greenhouses in NH do not need supplemental light when scheduled for safe plant out dates.

Several situations exist, however, where a greenhouse crop could benefit from achieving a DLI higher than that provided by the sun, and supplemental lighting is beneficial or required in those situations. UNH Extension has a worksheet for calculating the supplemental light requirements entitled, "Supplemental lighting run time worksheet."

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For More Information

For more information on growing plants indoors, see the UNH Extension Factsheet *Starting Plants from Seed*.

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