UK COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF KENTUCKY—COLLEGE OF AGRICULTURE

HortFacts 40-04

LIGHT FOR PLANT GROWTH IN THE CLASSROOM

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Light is often the critical factor for the success of an experiment using live plants. From general observations, many people believe that plants can grow almost anywhere, however, this is not true. A plant science experiment requires very good light for the total period of the experiment to be sure that plant growth occurs at near its optimum.

Light drives the growth of plants. However, it is not so much light as perceived by our eyes, as it is the energy of the light. Radiant energy is used by plants through photosynthesis to make the new compounds in the plant that result in plant growth. Radiant energy is converted to chemical energy that can be used in the plant. This chemical energy is found in various compounds but the first one that we see in the photosynthetic process is sugar. Depending on the type of photosynthesis these sugars may be 6-carbon or 4-carbon sugars. These sugars are transported throughout the plant, are broken down through normal plant cell metabolism and the plants use this energy for growth.

Important Characteristics of Light or Radiant Energy

The radiant energy that comes from the sun is a superb source of light for normal plant photosynthesis. Artificial light can also offer the necessary radiant energy for plant growth. Three factors must be considered when a discussion of light or radiant energy is made for growing plants indoors. These three factors are the intensity (total amount of light received), the duration (how long that this light is received each day) and the quality of light (the differences in color or wavelength in light). The differences in color may not always be apparent to the human eye but they are certainly apparent to the plants that are growing under these certain types of light.

Light **intensity** is simply the total amount of light received each day, each hour or each minute. This is one of the main measures of light to know whether a certain light source will be sufficient for normal plant growth. Typically, a sunny summer day will offer 10 to 12 thousand foot-candles of light outdoors. At the same time indoors, light intensities may be as high as 1000 foot candles, next to a south exposure window. Ten feet away from this south exposure window, there may be as much as 100 foot candles of sunlight. Additionally, typical classroom lighting is designed to keep about 50 foot candles on the desk top. Light intensity varies significantly in and around the classroom, but these differences are not easily observed by our eyes.

High light plants, such as beans, tomatoes or corn, require 500 to 1000 foot candles of light for normal growth. Low light plants (most house plants) generally require about 150 to 500 foot candles of light for normal growth. Only a few plants (pothos, Chinese evergreen, parlor palm) can tolerate 50 to 100 foot candles for more than 6 months. In summary, light intensity is so low in a classroom, that it is quite difficult or impossible to grow plants, normally, in these locations.

Duration is the amount of time that light strikes the plants' leaves each day. It is generally measured in hours and generally termed day length. Please note that day length is also involved with control of morphogenetic responses in the plant. However, for our purposes day length is connected to the amount of light that plants receive. The intensity and duration have an

additive relationship for plants grown under natural or artificial light. A plant that receives 200 foot candles of light for 10 hours receives the same amount of light by receiving 100 foot candles of light for 20 hours. This relationship makes artificial lighting easier, especially when determining the use of various kinds of lamps that can be used for a plant growth experiment.

Light **quality** is another important feature to consider for plants indoors. Light quality is concerned with the various colors of light that are normally produced by any light source. In general, these various colors of light are split apart by a prism. A prism separates light into 7 main colors that are visible to the human eye. There are colors (ranges of light both higher in wave length and lower in wave length than visible light) that are also important to plant growth. These are in the ultraviolet range (higher wavelength) and infrared range (lower wavelength). The infrared range is more important for morphogenetic responses. The pigments in green leaves that absorb light energy absorb different colors of light and utilize it with different degrees of effectiveness. This is the main reason that some artificial light sources were manufactured for indoor plants. We have learned, however, that plants are quite adaptable and use light sources of any kind to collect enough light energy for photosynthesis.

Light for Plant Growth Indoors

Windows are certainly the best source of light for plant experiments in a school classroom. A large window with a southern exposure will be satisfactory. Plants should be one to three feet from the window, never further away. East or west facing windows may be satisfactory, north-facing windows are unsatisfactory. Another way to evaluate light levels is to be sure that plants receive full sun (i.e. sunlight falls on the foliage) for at least four hours and preferably six to eight hours every day. Light will be optimal for plant growth under these conditions and the variable(s) in the plant experiment should have the appropriate effect. If light is less than this amount, light will be a factor in the experiment and probably overrule any other effects that the experiment plans to show. A good experiment that demonstrates the scientific method will compare only one variable. If you allow light to become a confounding variable, the expected results will be distorted by the lack of normal growth that the plants will show simply due to insufficient light.

Artificial light, from various sources, can be satisfactory for plant growth in the classroom. Because light cannot be limited for a successful plant experiment, you must be sure that all the light that can be obtained from artificial sources is received by the plants in a fashion that they can use during the whole length of the experiment. **Normal classroom lighting is insufficient for optimal plant growth, especially for experiments**.

Fluorescent lamps are appropriate for experiments or demonstrations of 3 to 10 weeks long. **Fluorescent lights** in a large fixture (four to six tubes, 2' to 6' long) can offer sufficient light for short-term experiments, depending on the plant. Unfortunately, this light is still not enough, when compared to a window. Once an experiment goes beyond six to eight weeks (depending on the plant), plants get too large, especially if grown properly, and fluorescent lamps simply cannot supply enough light for normal plant growth.

Long-term experiments, two months or more, require a stronger light source if natural light is not available. **High intensity discharge** (HID) lamps generate the stronger light necessary for long-term plant growth or large plants. These fixtures are street lamps; you may see the yellowish or blue-white colored light on the streets in your hometown and around the school. High intensity discharge lamps generate high levels of light that would be disruptive during a school day in a classroom. They also generate a great deal of heat, use quite a bit of electricity and are quite expensive. However, they do offer they do offer the opportunity to do an experiment with the correct amount of light from an artificial source. HID lamps are commonly used for modern plant growth experiments in all plant science fields.

Lamps for Plant Growth Indoors

Fluorescent lamps have been used for plant growth experiment for a number of years. They are a common feature in growth chambers to be used for plant science experiments in many different areas. They can be used in the classroom quite conveniently as long as you know what to look for and choose these lamps properly.

The main type of fluorescent lamp used for plant growth is called **cool white**. Cool white is the cheapest and most common fluorescent lamp available on the market. Simply look in your classrooms and you will find that it is the major lamp used in lighting indoors, schools, office buildings, malls, stores, etc. In general, cool white offers the consistent quality of light suitable for plant growth. Specialty fluorescent lamps - Grow Lamps, Grow Lux, etc. - have been designed for the culture of plants under artificial light. These lamps produce light quality similar to the sun. They work fine but they are more expensive and have a shorter life than cool white lamps. Warm white fluorescent offers red light that is important for plant growth under artificial light. Typical recommendations would suggest a mixture of cool white fluorescent and warm white tubes. Additionally, a few incandescent lamps or bulbs could replace warm white tubes.

Fluorescent lights are relatively easy to set up for plant growth experiments. The fixtures can be obtained from any hardware store or department store. These fixtures may be two to eight feet long depending on the needs for plant growth in your classroom. The fixtures are relatively inexpensive, $15.00 to $30.00 for the fixture, electrical connections, ballast and two tubes. Most installations of fluorescent light should include six to eight tubes space over a width of 2 to 3 feet. This installation will generate enough light energy for photosynthesis and normal growth.

Fluorescent fixtures are easy to set up once a stand has been purchased or constructed, possibly in the school shop, to support the fixtures. The **light stand** should allow the fixtures to be hung at various heights above the plants. This will allow plants of various sizes to be used. Fluorescent lamps should be approximately 18 inches above the foliage. The amount of light that a plant receives from a light source, like a fluorescent lamp, is inversely related to the doubling of the distance from that source of light. If the lamp is moved to 9 inches, the plants will receive about twice as much light and will grow much better. If we reduce the distance to 4½ inches, the light intensity doubles again. For best plant growth, the lamps should be as close to the foliage as possible without burning them. Fluorescent tubes generally do not damage the foliage from heat, because they run relatively cool, but they may.

Most plants prefer a normal day-length; plant growth **lamps should operate eight to twelve hours each day**. If lamps operate 14 to 18 hours, plant growth will increase. In fact, artificial light can be extended to 24 hours to enhance total plant growth. However, it is preferred not to use artificial lighting for 24 hours a day because plants really do need a dark period, at least as older stages of growth occur. A **time clock** or controller should be purchased to control the lighting. Time clocks are available from many sources, such as hardware stores, home stores, plumbing, electrical, greenhouse supply companies. Choose simple ones, such as those for home security, or ones that are more complex. These controllers cost in the range of $15.00 to $70.00 depending upon what it is that you want to do with the time clock fixture. Lamps can operate during the day or as school closes so they don't disrupt the classroom. They can operate from 4:00 p.m. to 4:00 a.m. and no one would know that the plants were receiving all this light except the plants.

Incandescent lamps are the most common type of light that students will know about. These are typical light bulbs used in most lamps in the home. **Incandescent lamps** have almost no value for plant growth indoors. The high amount of red light produced by this light source will distort plant growth dramatically. The "plant growth" light bulbs can be used to supplement natural light and may work in that fashion, but they cannot be used as a sole light source. Incandescent bulbs can cause distorted effects in plant growth that will totally confuse the effects that you would hope to see in your experimental procedure. Incandescent lights are quite inexpensive fixtures are easy to install, easy to operate and are easily controlled by time clocks plus they are easy to handle around the plants. However, the distortions caused by the light produced in an incandescent bulb and the high amount of heat they produce, make them a poor source for artificial lighting experiments in the classroom.

High intensity discharge lamps are the most sophisticated form of lighting for plant experiments in the classroom. The fixtures are commonly available and cost approximately $250.00 to $500.00 each. It is best to purchase low

profile HID lamps designed for greenhouse use rather than industrial fixtures. The fixture and reflector can be suspended 5 to 8 feet above the plants. The light intensity produced by these HID fixtures is sufficient to supply the photosynthetic needs for a large plant, so experiments could run for 5 or 6 months using this kind of fixture. Long-term experiments can be quite elegant in the classroom to show plant growth over a long period.

High-pressure sodium, metal halide and mercury vapor HID lamps would be satisfactory for classroom use. These lamps can be controlled by time clocks so that they are not disruptive to the normal classroom routine. They would be quite easy to suspend in the corner of the room with the experimental plants beneath them. They could also be installed in a storeroom, hallway, or other prep area so that students would not have to worry about the plants very often but plant growth would just continue. These lights can be turned on by a time clock at 4:00 in the afternoon and run through much of the night and turn off automatically and students not be affected by light from this bright source.