# Assimilation Lighting for Greenhouses


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*Bartok Jr. J.W. 2003. Assimilation lighting for greenhouses. In: Riley L.E., Dumroese R.K., Landis T.D., technical coordinators. National Proceedings: Forest and Conservation Nursery Associations—2002. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station. Proceedings RMRS-P-28: 74–75. Available at: http://www.fcnanet.org/proceedings/2002/bartok.pdf*

**Key Words**

Photosynthesis, light sources, measuring light, photoperiodism, lighting system selection


Visible light provides the source of energy for plant growth. Considerable intensity and duration are needed to get good plant growth. That is why plants grow better during the summer when the light is stronger and the days, longer.

Visible light is a composite of wavelengths from violet to red (380 to 780 nanometers [nm]). Light with wavelengths below 400 nm is called ultraviolet and can be harmful to plants in large quantities. Far-red light (700 to 750 nm) in combination with red light controls germination and, in combination with blue light, keeps plants from becoming too short or tall.

Sunlight is adequate for plant growth in most sections of the US for most of the year. In late fall, winter and early spring, short days and cloudy weather may limit the amount of light available. A rule of thumb states, "1% reduction in light results in 1% reduction in growth." Structural design, glazing materials, orientation of the greenhouse and other factors have a significant influence.

Supplemental lighting is used to:

1. Maintain optimum growth and get uniform crops (photosynthesis).
2. Regulate germination, rooting growth, stem elongation and flowering (photomorphogenesis).
3. Vary the day length to keep tree seedlings from going dormant (photoperiodism).

## Photosynthesis

With light as the energy source, carbon dioxide, and water are combined to give carbohydrates and oxygen. The carbohydrates are then translocated to various parts of the plant and transformed into other compounds for growth or maintenance.

Most plants can only utilize a limited amount of light called the saturation level. For example, the saturation levels for various species are: white oak – 1400 foot-candles (fc); northern red oak – 3300 fc; Douglas-fir – 3000 fc; Sitka spruce – 3000 fc; western hemlock – 3000 fc; loblolly pine – 9300 fc; and ponderosa pine – 11,100 fc. To get this level to the lower parts of the plant or for seedlings that are spaced closely together, levels 2X to 3X more may be needed.

## Light sources

While almost any light source can be used for photosynthesis, some are much more efficient. Knowledge of the light source's construction, efficiency, and electrical characteristics is useful in making the best choice for plant lighting.

### Incandescent

The standard incandescent bulb is used mainly for daylength control. Its short life and low light output per watt of electricity input have limited its use. Efficiency: 10 to 20 lumens/watt.

### Fluorescent

These bulbs are commonly used in growth rooms where more uniform lighting is needed. Lamp life is about 12,000 hours. For most horticultural applications, cool white or warm white bulbs will give good growth. With special design, banks of lights can provide up to 2000 fc. Efficiency: 30 to 75 lumens/watt.

### High-intensity Discharge (HID)

This is the standard bulb for photosynthetic lighting in greenhouses today. Lamps contain a mixture of gases and metals enclosed within a glass tube. As electricity passes between the electrodes at the ends of the tube, the gas/metal mixture heats up and emits light. Bulbs are available from 75 to 1000 watts. Lamp life is 24,000 hours. Efficiency: 80 to 120 lumens/watt.

HID lamps can be either high pressure sodium (yellow light) or metal halide (white light). Sometimes a combination of both types of bulbs is installed to give a more uniform spectrum.

Reflectors are used to direct the light toward the plants. When selecting a reflector, look for uniform distribution of the light at plant level and highly polished surfaces that keep dirt accumulation to a minimum and diffuse the light. Contact the manufacturer to get a computer analysis of the best height, spacing, and location for fixtures. This usually results in more fixtures being required at the edges of the growing area than in the middle.

## Measuring Light

Light can be measured in photometric or quantum units. Photometric units (foot-candles) have been the standard for many years and most printed recommendations use these units. Measurement is made with a low-cost foot-candle meter similar to a light meter on a camera. Typical greenhouse supplemental lighting levels for tree seedlings might be in the 600 to 900 fc range. Germination/growth room levels may be in the 1000 to 2000 fc range.

Quantum units [(micromoles of photons/$m^2 \cdot s$)] more accurately represent what the plant sees. Most current research is being reported in these units. Photosynthetically active radiation (PAR) is a measure of quantum units in the 400 to 700 nm range utilized by plants. A PAR meter is used. The above typical greenhouse readings in fc would convert to 79 to 118 $\mu$mol/($m^2 \cdot s$) if high-pressure sodium bulbs are used. Other types of bulbs have different conversion factors.

Light measurement can be made as an instantaneous reading or can be integrated and accumulated over a day. Instantaneous readings are good to establish the level at which supplemental lighting can provide, and its uniformity. But it is the total light integral, the sum of the sunlight plus the artificial light that the plants receive, that is important. On a cloudy day, more supplemental light is needed than on a sunny day to provide the plant requirements. The total light integral is made by placing a PAR sensor at the top of the plant canopy and connecting it to a computer that does the integration. The computer software makes the decision on when to turn on the supplemental lights. It may also include evaluating the cost of electricity at different times of the day.

## Supplemental Lighting System Selection

Several factors should be considered before purchasing supplemental lighting equipment.

**Light intensity**. Determine what level of supplemental light is needed on the darkest day to make up the total light integral the plants need. Don’t install more than is needed.

**Distribution**. Select and locate fixtures so that they create the least amount of shadow. Location under trusses or retracted curtains reduces the amount of shading.

**Uniformity**. Check light intensity uniformity once lamps are installed.

**Cost of operation**. Supplemental lighting should not be operated more than is needed. Utilize off-peak electricity rates and long term purchase power agreements where available.

**Maintenance**. Develop a lamp replacement schedule and reflector cleaning program.

## Photoperiodism

Photoperiodism is the response of plants to the day-night cycle. It can affect flowering, tuber and bulb formation, the shape of newly forming leaves, red pigmentation in bracts of plants, and dormancy in tree seedlings. Photoperiod can be extended by providing continuous light, either after sunset or before sunrise, or by interrupting the dark period with intermittent lighting. Light intensity needed varies with species from about 5 to 30 fc. The light source should have some red spectrum in it.

With intermittent lighting, the duration of the light during the dark period must also be controlled. A dark period no longer than 30 minutes and a light period of 1 to 2 minutes works well on most plants.

Intermittent lighting can be provided with incandescent bulbs connected to a power line stretched over the growing area. Reflectors will distribute the light over the bench. A new light source, Beamflicker, (Hydrofarm Inc, Petaluma, California) utilizing a 400 or 600 watt sodium vapor bulb with an oscillating reflector has been developed and is being tested. One 400 watt fixture will provide a minimum 10 fc to a 30 x 100 foot greenhouse. This unit is much less expensive to install and operate than incandescent bulbs.