Measuring Light

Looking At Light

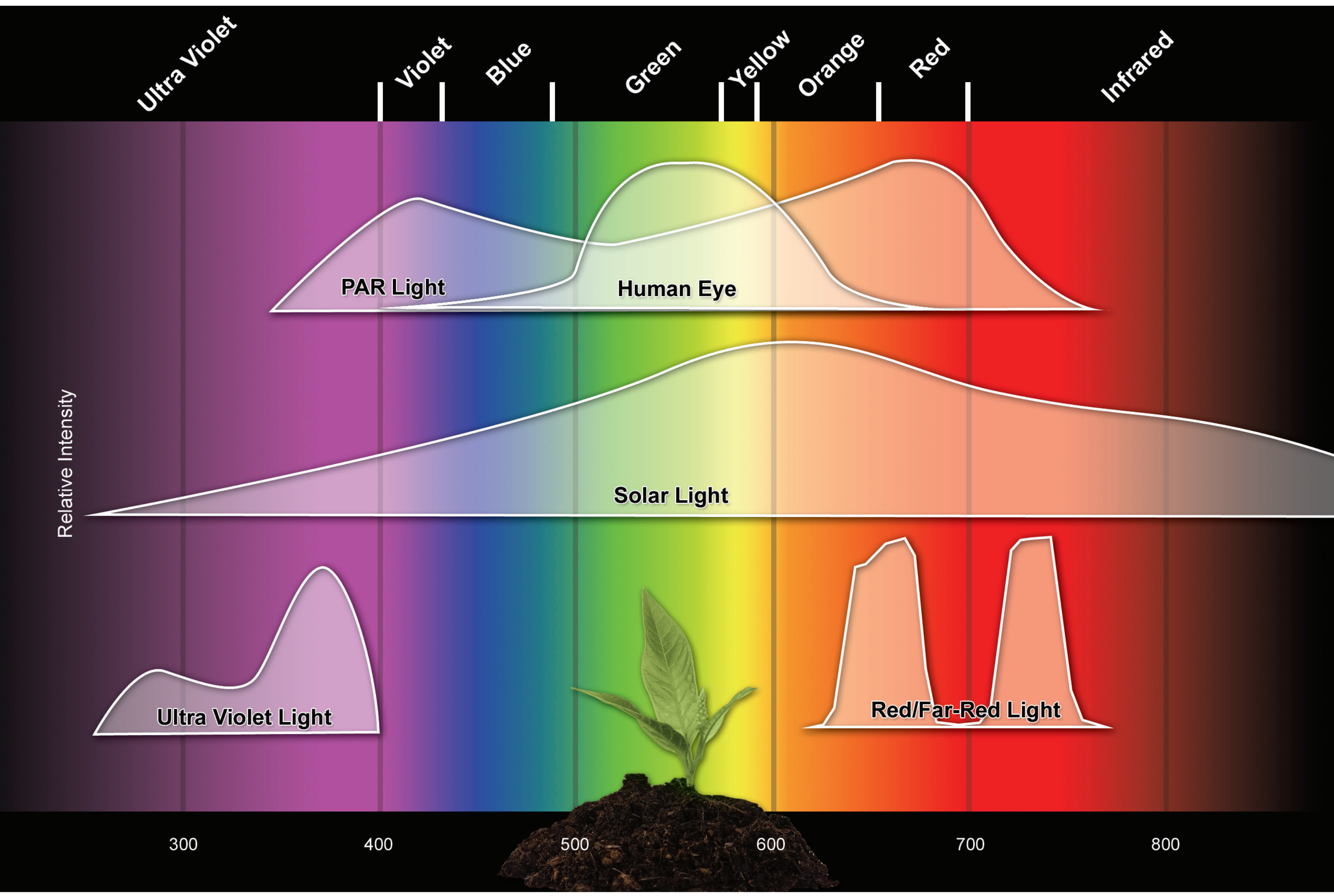
How do your plants feel today?

LIGHT HAS ECONOMIC VALUE

As the driving force for photosynthesis, light is fundamentally important to crop production. Plant growth and development is significantly influenced by both the quantity and the quality of light. Light energy is relevant to other factors too. The ET calculation (evapotranspiration) for irrigation scheduling uses solar radiation as a key variable. Leaf wetness periods or high humidity, which affect disease pressure, can be mitigated with sunny days versus cloudy days. It is essential that growers understand this important variable in order to efficiently produce quality plants.

Nanometers	Term	Effects
280-315	Ultra Violet	Small influence on morphogenetic and physiologic processes, bleaches colors, causes sunburn, causes some fungus sporolation
315-400	Ultra Violet - Blue	Slight absorption by chlorophyll, influence on photoperiodism, inhibition of cell elongation, sunburn, causes some fungus sporolation
400-520	Blue	High absorption by chlorophyll and carotenoids, big influence on photosynthesis
520-610	Green	Low absorption by pigments
610-750	Red	Low absorption by chlorophyll, big influence on photosynthesis and photoperiodism, blocking may slow stretch
750-1000	Far-Red	Low absorption, stimulation of cell elongation, influence on flowering and germination, blocking may slow stretch
1000 +	Infrared	HEAT - energy absorption is converted into heat

MEASURING LIGHT ACCURATELY REQUIRES THE RIGHT METERS AND METHODS



How Does Light Affect My Plant Growth?

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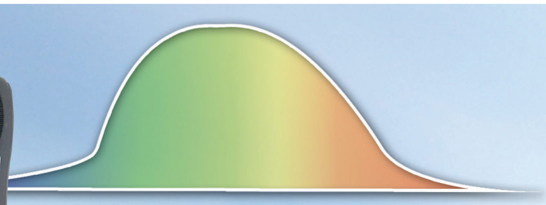

HUMAN EYE PERCEPTION (500-600nm)
Foot Candle or Lux meters measure light similar to how the human eye perceives brightness: strongest in the 500-600nm range. Though this is desirable for photography and interior design, plants react to light differently.

"Measuring DLI inside the greenhouse can be very revealing, since growers usually rely on their eyes to determine the light levels and the human eye is a terrible light sensor because it is so effective at adjusting to different light environments."

James E. Faust
Associate Professor of Horticulture
Clemson University

WHAT IS LIGHT?
Waves: Light is electromagnetic waves. The wavelength is measured in nanometers (abbreviated nm).
Particles: Light is photons, which are a quantum, or individual unit. Since individual photons possess tiny amounts of energy, photons are measured in units of moles (abbreviated mol), which are each 6.02×10^{23} photons. Micromoles (abbreviated μmol) are one-millionth of a mole.

QUALITY
Photons have different amounts of energy, determined by their wavelengths. Light quality is the relative number of light particles at each wavelength. Light quality refers to the spectral distribution of light, or the relative number of photons of each portion of the light spectrum (visible and invisible) emitted from a light source.

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PAR / QUANTUM LIGHT (400-700nm)
The light that drives photosynthesis in plants is Photosynthetically Active Radiation, or PAR light. This is also referred to as Quantum light, because it is measured in units of moles striking an area over time. Though PAR light ranges from 400 to 700nm, the region brightest to human eyes is the area of least effect on plants. Measuring quantum light can tell you if your plants are getting a sufficient amount of usable light.

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QUANTITY
Most light meters measure light intensity – the instantaneous amount of light delivered to an area. Units include foot candles and lux (for people), Watts/m^2 (for solar radiation), and μmol/m^2s (for plants).

If photons were raindrops, light meters would show the intensity of a rainstorm. A five minute rainstorm may look impressive, but often provides less water than an all-day drizzle. As cumulative rainfall is measured with a rain gauge, the cumulative quantity of light is measured using a light sensor with a data logger. Daily solar radiation is often measured in MJ/m^2day. The daily total of quantum light is called the Daily Light Integral, or DLI, and is measured in units of mol/m^2day. DLI quantifies the light available to plants to perform photosynthesis.

On a sunny winter day in the middle latitudes, a plant receives about 9 moles/day. If it is cloudy, the DLI drops to 3 moles/day. In the summer, the DLI for a sunny day is about 26 moles/day and 12 moles/day for a cloudy day.

Each type of plant has a different DLI range for optimal growth. DLI is directly correlated with plant quality, and a minimum amount of light is required for marketable plants. Measuring DLI over a growing season and comparing it to results can help a grower decide which varieties work for his or her location.

LIGHTSCOUT®

LIGHT METERS

SOLAR RADIATION (300-1100nm)

The sun radiates a broad range of light from 300-1100nm. In agriculture, this total radiation is needed primarily to calculate Evapotranspiration (ET). ET is the amount of moisture leaving the ground through evaporation (from the ground) and transpiration (from the leaves), and is dependent upon light, wind speed, temperature, and relative humidity.

UV (200-400nm)

Plants can suffer from sunburn; exposure to radiation in the mid-ultraviolet part of the electromagnetic spectrum (UV-B) triggers stress responses, inhibition of photosynthesis, and DNA damage. As an initial defense, plants produce and accumulate UV-B-absorbing chemical sunscreens, such as flavonoids and sinapate esters, to block low-dosage UV-B.

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A UV meter can help detect if your plants are being exposed to high levels of detrimental UV radiation, and to check the effectiveness of UV filtering materials. In general, a UV meter will measure the quantity of light in the 250-400nm range. Specific meters are also available for individual UV ranges.

UV-C light (200-280nm) can kill your plants. Fortunately, it is absorbed by ozone in the stratosphere.
UV-B light (280-315nm) is harmful as well, and can cause plant color to fade.
UV-A light can be subdivided into two bands. The 315-380nm band has no effect on plant growth, while the 380-400nm band begins the range for photosynthesis.

RED/FAR-RED (660/720nm)

Plants absorb red light (660–680nm) and reflect far-red light (720–740nm). Plants contain phytochromes, photoreceptors that control physiological and developmental reactions to fluctuations levels of red and far-red light. Some responses that are regulated by phytochromes include germination, stem elongation, flowering, and gene expression, as well as leaf and chloroplast development.

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Plant leaves filter light, allowing more far-red light to pass through than red light. This changes the red to far-red ratio below the canopy. Similarly, a low red to far-red ratio is created when plants are close together.

Knowing your red to far-red ratio can help you determine plant spacing and decide when to apply plant growth regulators. Greenhouses with high canopy closure or canopy density may need more applications of plant growth regulators to keep the plants a marketable size.

EXAMPLE RED TO FAR-RED RATIOS	
Sunlight	1.2
Under a canopy of leaves	0.13
Under 5mm of soil	0.88

“Far-red light plays a significant role in plant growth. It is a major factor in promoting the shade avoidance (stem elongation, stretching) response in plants. We cannot sense far-red so having a meter that lets us know how much far-red and red light (which counteracts the effect of far-red) plants are receiving, especially within the canopy, is very useful. The meter can help a grower appropriately space plants so that they are given enough space to grow properly but not so much that space is wasted.”

Peggy McMahon
Associate Professor - Department of Horticulture and Crop Science
Ohio State University

Spectrum Technologies – "To Measure Is To Know"

Measuring Light

Individual light sensors, available individually or as a bar of 3 or 6 sensors, allow you to measure site-specific areas. These hand-held sensors feature cosine correction, built-in levels, and mounting brackets for stationary measurements. Light Bars are frequently used when measuring across a greenhouse bench.

3415FX	**FieldScout External Light Sensor Meter**
3668I	**Quantum Light Sensor**
3668I3	**Quantum Light 3 Sensor Bar**
3668I6	**Quantum Light 6 Sensor Bar**
3676I	**UV Light Sensor**
3670I	**Silicon Pyranometer Sensor**

LEAF AREA INDEX
Leaf Area Index or LAI is the ratio of surface vegetation to total land area. One indirect method of calculation of LAI measures light intensity above the canopy and compares it to light intensity at ground level.

HOW DO I MEASURE LIGHT?
Light Bars take the average light reading for multiple sensors across a fixed length. This can be used to determine canopy density and light transmission.

WatchDog® WeatherTracker - *No Computer Needed*
Model 305 Greenhouse Growth Tracker

The Greenhouse Growth Tracker is a comprehensive tool used to assess physiological maturity of plants – without the need of a computer. The Growth Tracker measures plant light exposure over time (in moles/day) and also calculates day/night temperature differential. This stand-alone unit not only displays current conditions every 20 seconds but also stores up to 12 months of data summaries – without needing a computer!

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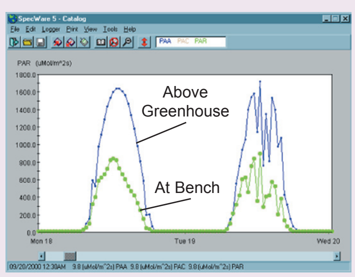
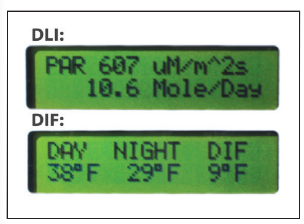
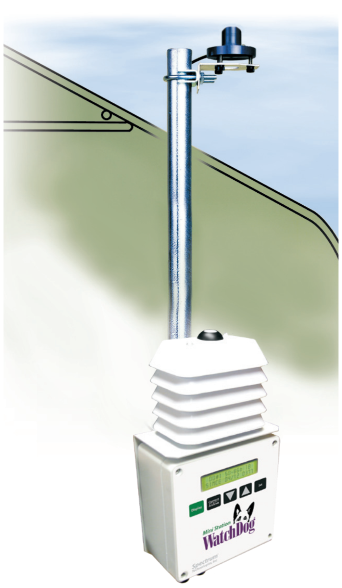


OUTSIDE LIGHT VS. AT THE BENCH
Glazing and greenhouse materials can cause light transmission to vary from 50-90%. Using 2 light sensors, one on the outside of the greenhouse and another at the bench, will allow you to calculate and track light transmission.





3686WD with 3668I Quantum Light Sensor

WatchDog Model 2475 Plant Growth Station

The Plant Growth Station monitors and records temperature, humidity, and light conditions within a greenhouse setting. Integrate with an additional quantum light sensor, and you are now able to compare available outdoor light to actual light reaching greenhouse benches — effective in tracking actual light transmission. Current and up to twelve months of historical data will display on the LCD screen. Average temperatures, light intensity, DLI, and day/night temperature differential are displayed on the LCD.

Resources:
J.W. Reed, P. Nagpal, D.S. Poole, M. Furuya and J. Chory. *Mutations in the Gene for the Red/Far-Red Light Receptor Phytochrome B Alter Cell Elongation and Physiological Responses throughout Arabidopsis Development.* Plant Cell. February 1993, 5(2): 147-157.

Erwin, J.E., Rohwer, C. and Gesick, E. *Red:Far Red and Photosynthetically Active Radiation Filtering By Leaves Differs With Species.* Acta Hort. (ISHS) 711:195-200.

L Ellington. *Klerk's Growlite.* 2nd Quarter 2003. Klerk's Plastic Products Manufacturing, Inc.

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