



7. Light

Light is essential for photosynthesis. Consequently, light will influence many growth processes such as photosynthesis, water and nutrient absorption and also affect quality. Low light intensity is often the limiting factor for plant growth. Under low light conditions, the number of days to harvest period is extended and the average weight is reduced. The optimum temperature to obtain the maximum increase in dry matter depends on the light intensity. Light also influences other climatic variables inside the greenhouse such as temperature which in turn influences humidity levels.

	Plant	Hours of Direct Light							Don't light for > 12 hours
		4	5	6	7	8	9	10	
greens	Lettuce								
	Arugula								
	Kale								

Table 10. Direct Sun Light levels for greens

Global Solar Radiation (GSR) refers to the full spectrum of electromagnetic wave lengths coming from the sun. GSR is composed of:

Radiations Types	Wavelength (nm)	Percentage of GSR
Ultraviolet (UV)	300-400	2 to 4%
Visible light and PAR ¹	400–700	45 to 50%
Infrared (IR)	>700	50%

Table 11. Photosynthetic Active Radiation

7.1 Light Measurement

Two kinds of light information are important for plant production: Light intensity and light accumulation. Light intensity is basically the amount of energy falling on a surface at any instant. It corresponds to the brightness of the day. Light accumulation or light sum is the total accumulated light for a whole day (photoperiod) or determined period of time. Light measures are used to adjust other climate conditions such as temperature, curtain, and irrigation settings.

Three types of sensors are available for greenhouses: Photometric sensors, Radiometric sensors (Solar meters or Pyranometers) and Photosynthetic Active Radiations (PAR) sensors. Each one is sensitive to a different part of the light-energy spectrum.



Sensor	Light spectrum	Light Intensity Units	Light Accumulation Units
Photometric	Visible to human eye	Klux Foot-candles	Klux hours Foot-candles
Radiometric (solar meters)	Global Solar Radiation	mW/cm ² W/m ²	J/cm ²
Quantum light meter	PAR ¹	μmol/m ² /s	mol/m ² /day

Table 12. Photosynthetic Active Radiation

7.2 Light Management in Low Light Conditions

- In northern latitudes during fall and winter months, the available light will be limiting for optimal plant growth.
- Keep the cover material of the greenhouse as clean as possible in order to increase light transmission.
- Increase the reflectivity of light in the greenhouse which allows maximum use of transmitted light.
- Using artificial lighting as a supplementary source of light when possible.

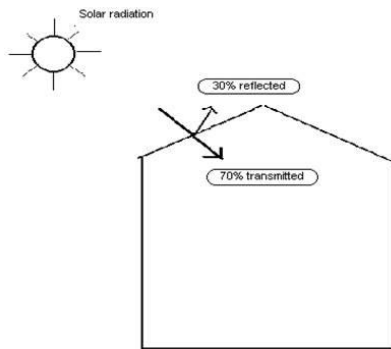


Diagram 3. Sun Reflection-Transmission

7.3 Light Management in High Light Conditions

- I can not say high light levels are beneficial to optimum plant growth, Light is a necessary for plants but should be optimum level since high level light giving burning effects to the plants or the leaves losing moisture easily.
- Reducing light levels may be accomplished by closing the shade curtains or whitewashing the greenhouse roof if curtains are not available.
- Shading the crop is recommended when a very sunny period follows a few days of cloudy weather. This can be accomplished by changing the shade curtain settings on the environment computer.



- After transplantation to the production area, it could also be profitable, to close the curtain a little bit earlier to avoid wilting of the transplants, especially in the case of big transplants.

Configuration and Intensity of Supplemental Lighting

The total light integral received by crop once plants are floated in the ponds should be at least 10-17 mol/m²/d. Supplemental light must be used if this amount of PAR cannot be obtained with sunlight only (because of the time of year, light reduction due to shading by greenhouse components, or decreased light transmission because of greenhouse covering).

Lamps should be configured for a uniform distribution of light over the entire growing area. Light intensity is maintained at no less than 50 μmol/m²/s¹ of PAR during the first 24 hours the seeds are kept in the germination area but not more than 100 μmol/m²/s¹. This level of illumination prevented stretching of the seedlings while minimizing the tendency of supplemental lighting to dry out the surface of the medium. Instantaneous light intensity can be measured with a PAR meter.

For the remaining 10 days, the light intensity is maintained at no less than 100 μmol/m²/s¹. The photoperiod (or day length) may be up to 20 hours. Shorter photoperiods are acceptable if the light intensity is increased to provide the same total daily accumulated light (~17 mol/m²/d¹).

Note for germination rooms: Light output of cool white fluorescent (CWF) lamps decays over time. Thus, it is important to measure the light output of the lamps regularly. If the light intensity drops below an acceptable level (e.g. 200 μmol/m²/s¹), new lamps should be installed. A quantum sensor can be used to measure the amount of PAR.

Uniform light distribution is required in the Pond Growing Area. A supplemental light intensity within the range of 100-200 μmol/m²/s¹ (for a total of 17 moles m⁻²d⁻¹ of both natural and supplemental lighting) at the plant level is recommended. It should be noted that we did not experimentally optimize daily light integral. High pressure sodium (HPS) lamps are a type of High Intensity Discharge (HID) lamp and are used to supply light. These lamps are relatively efficient, have a long life (~25,000 hours, generally these lamps lose 1% output for every 1000 hours), and slowly decay in output over time. There is a recent development in the manufacturing process for metal halide lamps that gives them a lifetime similar to high pressure sodium lamps. Metal halide lamps have a spectrum that is slightly more efficient for plant growth than high pressure sodium lamps. A new bulb produced by the Philips Corporation has exaggerated the benefits of metal halide lamps including shifting more light production to the blue and red portions of the spectrum and decreasing the heat output of the luminaire. Independent lighting consultants have specialized software to determine proper number and placement of lamps needed for a specific and uniform light intensity. It is critical to have the correct lighting system installation.



Picture 63.

Now a days we are also using LED or mix with HPS like we call hybrid system Please firstly decide your crop than select the variety needs for lightening. So, you may choice right system and light level accordingly.

7.4 Specialty lighting

- Recent development in LED lighting systems permit to supply lighting specially designed to enhanced deeper coloration; lots of LED manufacturer on the market, but very few know about plants growth and needs.
- Until now acquiring costs make the choice difficult to do Vs HPS lighting because of price difference; for sure lower electrical consumption do compensate up to a point but still, acquisition costs remain a limitation.
- An approach has been developed and tested with coloration to expose plants to specially designed LED for only the last 33% of their growing cycle, thus reducing greatly the related investment.

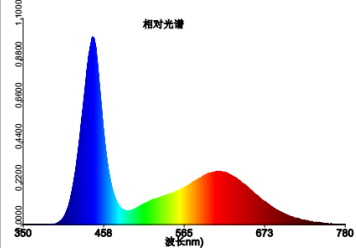
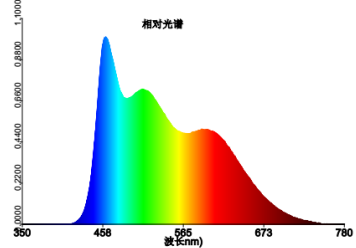
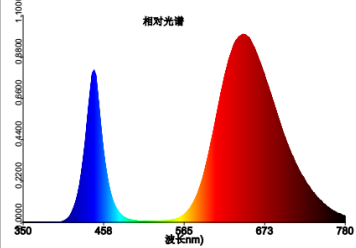
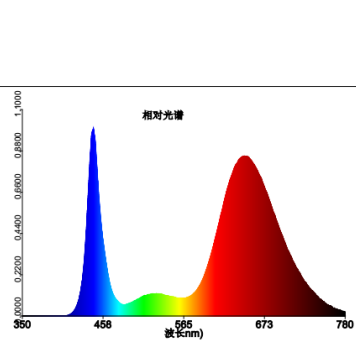
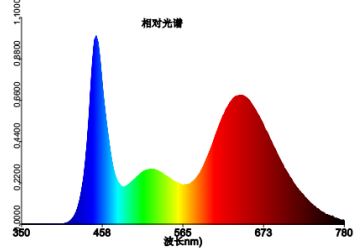
7.5 Suitable spectrums for the plants.

I find useful table which is show us different spectrums for different crops. There are many different ratios supplied by the LED companies, but I guess this is the summery what we need as grower.



		Suit for	function
1		<p>Suitable for strawberries, big shed scarlets, melon leaf vegetable nursery period, hemp, meaty。</p>	<p>Light color is pink purple, red light makes plants grow, blue light promotes protein and non-carbohydrate accumulation, so that plant weight gain。</p>
2		<p>Suitable for strawberries, big shed scarlets, melon leaf vegetable nursery period, hemp, meaty。</p>	<p>The light color is pink-purple, blue light affects the plant's photo nature, light form, opening of the pores and the photosynthesis of the leaves, and the material generated by the red light makes the plant grow tall.</p>
3		<p>Suitable for outdoor dragon fruit, flowers, water and grass, melon fruit to complement light, long-term</p>	<p>Light color is warm color, blue-green light makes chlorophyll and rhododole ratio is large, photosynthesis is significant, red light makes photosynthesis cycle effect has an effect.</p>
4		<p>Suitable root, root crop class, ornamental gardening, plant walls, growth of seedlings, multi-meat to niche.</p>	<p>The light color is white, the spectrum is saturated, and the plant is rich in photosynthesis, forming chlorophyll absorption.</p>
5		<p>Suitable for sprouts, roots, vines。</p>	<p>Light color is warm pink, green light and red and blue light harmoniously adjust edifying to adapt to the growth and development of plants, red and blue LED composite light, plants slightly purple gray, making disease and disorder symptoms are not easy to diagnose, can be resolved by supplementing a small amount of green light.</p>



7	 <p>相对光谱</p> <p>350 468 565 673 780</p> <p>波 (nm)</p>	Suitable for flowers, plant factories, melon fruits, tomatoes (tomatoes), long-term。	Light color is pale pink, improve flowering, melon fruit production, adjust plant form, conducive to fruit and vegetable VC and sugar synthesis。
8	 <p>相对光谱</p> <p>350 468 565 673 780</p> <p>波 (nm)</p>	Suitable for ornamental flowers, vines, ferns, multi-meat plants to complement the light.	Light color is white, combined with effective radiation, promotes the accumulation of protein and non-carbohydrate, so that plant weight gain。
9	 <p>相对光谱</p> <p>350 468 565 673 780</p> <p>波 (nm)</p>	Suitable for sprouts, leafy vegetables, melon fruit nursery period.	The light color is powdered purple, the proportion of red blue light is uniform, promotes carbohydrate travel, while inhibiting the growth extension of the stem, and promoting chlorophyll synthesis.
10	 <p>相对光谱</p> <p>350 468 565 673 780</p> <p>波 (nm)</p>	Suitable for sprouts, roots, vines。	Light color is warm pink, green light and red and blue light harmoniously adjust edifying to adapt to the growth and development of plants, red and blue LED composite light, plants slightly purple gray, making disease and disorder symptoms difficult to diagnose, can be resolved by supplementing a small amount of green light。
11	 <p>相对光谱</p> <p>350 468 565 673 780</p> <p>波 (nm)</p>	Suitable for plant factories, tissue culture, leafy vegetables, flowers, melons and fruits, meat, strawberries, cucumbers, tomato lamps.	Color light is white, chlorophyll and hoclave-like absorption is moderate, carotenoid mainly absorbs blue-purple light, that is, red light and blue-purple light for photosynthesis of the most effective photo response.



12		<p>Suitable for outdoor dragon fruit, flowers, water and grass, melon fruit to complement light, long-term</p>	<p>Light color is warm color, blue-green light makes chlorophyll and rhododole ratio is large, photosynthesis is significant, red light makes photosynthesis cycle effect has an effect.</p>
13		<p>Suitable for outdoor dragon fruit, flowers, water and grass, melon fruit to complement light, long-term</p>	<p>Light color is natural light, the spectrum is saturated, promotes plant-rich photosynthesis, forming chlorophyll absorption.</p>
15		<p>Suitable for flowering results, sprouts, lilies, apricots, crucified, melon fruit.</p>	<p>Light color is warm color, red light is built by photosensitive pigment control light form, red light is driven photosynthesis by photomochrome absorption, red light promotes stem elongation, promotes carbohydrate synthesis, is conducive to flower growth, flowering period is extended.</p>
16		<p>Suitable for leafy vegetables, stems, apricots, lilies, twelve rolls, melon fruits, seedlings.</p>	<p>Light color is light purple, blue light affects the plant's photonature, light form, opening of pores and photosynthesis of leaves, blue light combination spectrum blue light ratio can promote the growth and development of seedlings.</p>

Table 13. Suitable light types for crops.

We will talk about CO₂ for next subject, but I just would like to give some diagram about light/CO₂ correlation and how effect to plant growing by their ratio. Which means only light or only CO₂ has not much meaning if other not enough. So here are 3 different diagram showing same things for better understanding.



Increasing light availability →

	1400 Lux	5400 Lux	15200 Lux
0.7 mg/L	1.1%	3.3%	6.5%
6.6 mg/L	3.8%	9.2%	10.5%
35.2 mg/L	4.1%	10.3%	14.8%

↑ Increasing CO₂ concentration

Table 14.

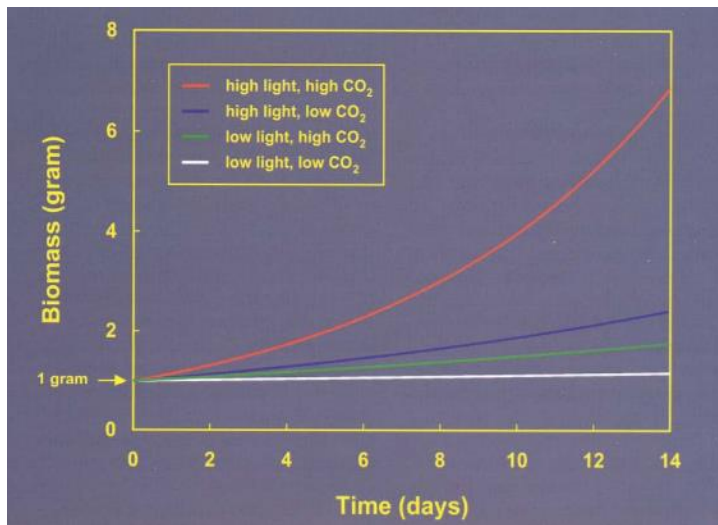


Table 15.

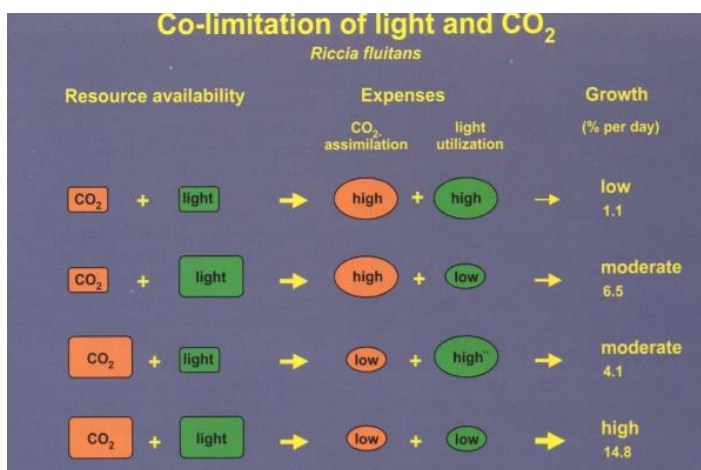


Table 16.