LIGHT

Stages of Plant Growth
&
Shifting Light Needs

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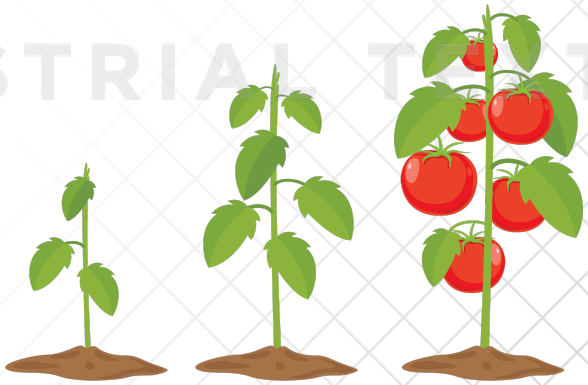
Role of Textiles During Crop Development

Crops need light and a specific amount of warmth to achieve optimum characteristics for the market place

Too much light or heat →

Too little light or heat →

Using specific textiles based on location, crop, time of year and crop stage of development, these slides provide guidance to achieve healthy, happy plants.



Phases of Crop Growth

Phases

1. Germination
2. Seedling
3. Vegetative Growth
4. Flowering
5. Ripening

Phases of growth are generalized to provide basic information across many plant types. Specific varieties/cultivars can vary in development stages.

Identifying Optimal Light

Key Aspects Defined

- Photosynthetically Active Radiation (PAR):
  - Light needed by crops: full light spectrum (~400 - ~ 700 nm wavelength)
  - Roughly blue to Red
- Photosynthetic Photon Flux Density (PPFD):
  - Amount of PAR light that reaches a specific area
  - Measured in micromoles per square meter per second (mol/m^2/second)
  - Can be measured with a photometer above crops or cell phone app
  - Varies by season and location
- Daily Light Integral (DLI)
  - Amount of PAR light a crop needs for photosynthesis
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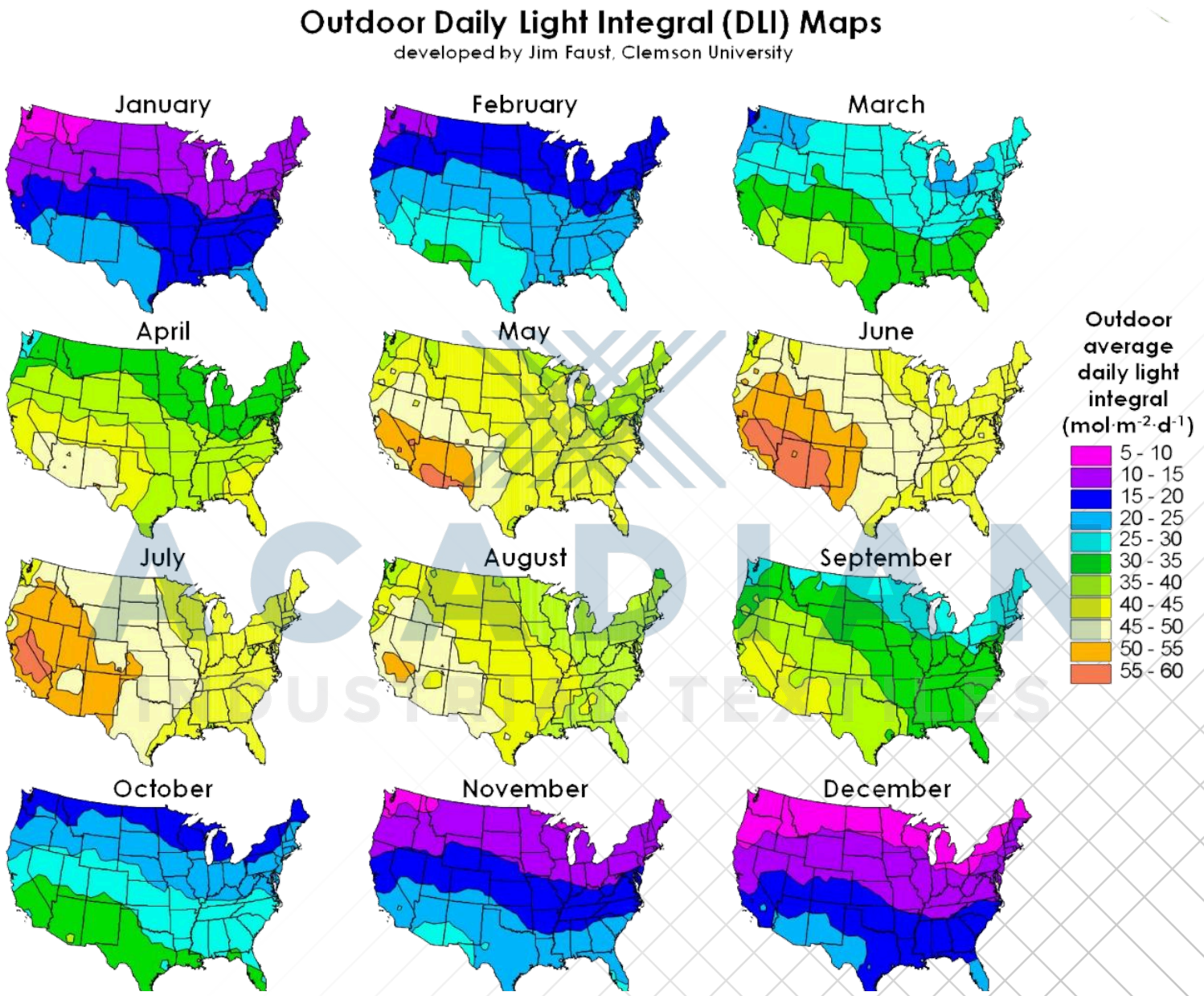
  - Varies by stage of crop development
- Photoperiodic plants: transition to different development stages based on cues from length of day
- Photoblastic plants: require light for germination

Optimal Light information provides basic information across many plant types.
Specific varieties/cultivars can vary greatly in light or heat requirements.
To provide examples, common crops with specific needs are listed.

Daily Light Integral by Region



Germination/ Seedling	Seedling	Vegetative Growth	Flowering	Ripening

What's Occurring (mostly applicable to vegetables, legumes, nuts)

- Seeds absorb water
- Begin metabolic and initial root processes
- Once seeds open, photosynthesis starts
- Shoots are reaching for light; typically need a lot of bright, indirect light

Light Color Impact:

- Red, Far Red Light: can trigger their germination in photoblastic seeds

Role of Shade Cloth, Polyfilm or Curtain:

- Keep environment dark until seeds sprout shoots
- Deliver Far Red or Red light through Rose colored Shade

Germination/ Seedling	Seedling	Vegetative Growth	Flowering	Ripening

Role of light:
Generally, the heat generated by light plays a larger role than light itself

- Beets and Spinach: 4-6 hours direct light (photoblastic crops)
- Peppers and Tomatoes don't need light
- Spinach needs some warmth but does best in temperatures under 70F

Specific Crops and their Textiles:

- Beets and Spinach: Need PAR light either directly or through film/ curtain
- Peppers and Tomatoes: May need darkness
  - Dense shade cloth 70% or higher
  - Opaque, black out or panda film/ curtain that can be easily changed or moved for seedling phase to allow light

Germination/ Seedling	Seedling	Vegetative Growth	Flowering	Ripening

What's Occurring?

- Most plants are using photosynthesis to make food
- Roots deepen
- Shoots flourish as leaves open
- Plants shift from using nutrients in seeds to gathering their own

Light Color Impact:

- Red/blue balance (Rose) in low intensity promotes:
  - Stem and root growth
  - Leaf expansion
  - Increase in number of tomato, which improves photosynthesis efficiency
- Blue light plays largest role in chlorophyll creation
- Daily light requirements are generally lower than in later development phases

Role of Shade Cloth, Polyfilm or Curtain : Temporarily limits light received by plant until vegetative phase

- Cloth:
  - Low shade amount allows bright light while limiting indirect light
  - White or Silver cloth can reflect excess heat away
- Greenhouse curtain or Polyfilm: Opaque or low transmission value

Role of light:
How much needed per day by crop and possible shade needs

- Beets: Early stage: 6 - 10 mol/m^2/day, later stage: 10-15 mol/m^2/day
- Peppers: 8-16 mol/m^2/day. 50% shade in mid-west
- Spinach: 8 - 12 mol/m^2/day 60% shade or higher
- Tomatoes: 8-16 mol/m^2/day unde 40% shade

Specific Crops and their Textiles:

- Beets, Peppers, Tomatoes: Clear film or curtain with over 70% or even 80% shade transmission allows to reach plants
- Spinach:
  - White or silver/grey shade reflects excess heat
  - Shade of 50% or more depending on geographic location and time of year
- Tomatoes: Opaque Hail or Bird net (low shade %)
  - Protects plant from inclement weather
  - Allows light through

Germination/ Seedling	Seedling	Vegetative Growth	Flowering	Ripening

What's Occurring?

- Roots continue to grow while majority of growth is in the leaves and stems
- Maximize photosynthesis possible by expanding available surface area (leaves are where most photosynthesis occurs)

Light Color Impact:

- PAR (full light spectrum): Need at crop specific daily light integral (DLI)
- Blue Light: Supports Chlorophyl production
- Red/Blue balance (Rose) in low intensity promotes:
  - Structural growth: stem and roots
  - Leaf expansion

Role of Shade Cloth, Greenhouse curtain or polyfilm: Select shade % or light transmission level based on crop DLI /PPFD

- Prevents leaf burn and stunted growth
- Reduces heat experienced by plant
- Controls crop exposure to light based on crop DLI or PPFD requirements
- Prevents premature flowering in specific crops by reducing day light hours for crops grown in early spring
- White or Silver shade cloth reflects excess heat away
- Spreads light around tunnel/greenhouse when there are various canopy levels
- Greenhouse curtain or Polyfilm can reduce heating costs with IR additive and prevent condensation from collecting on walls or ceiling with Anti drip additives

Germination/ Seedling	Seedling	Vegetative Growth	Flowering	Ripening

Role of Light: How much per day or at a given moment per crop (estimates)

- Beets: 12-20 mol/m^2/day, PPFD 200- 400
- Peppers: 20-30 mol/m^2/day, PPFD up to 600
- Spinach: 14-16 mol/m^2/day, PPFD up to 250
- Tomatoes: 22- 30 mol/m^2/day, PPFD up to 800

Specific Crops and their Textiles:

- Protection from adverse weather
- Beets: Canopy may benefit from diffusion above 30% in Polyfilm or curtain
- Peppers: 50% shade/transmission or lower prevents too much light on tender parts of plant
- Spinach: Keep temperatures below 80F and amount of light (PPFD) on plant under 400 µmol/m^2/s
- Tomatoes: Bird/hail, insect netting, or curtain generally provides protection from animals and pests while transmitting ≥ 70% light

Germination/ Seedling	Seedling	Vegetative Growth	Flowering	Ripening

What's Occurring? Energy use shifts from leaf and root expansion to flower and seed development

- Vegetables are often harvested before flowering
- Flower buds develop
- Prepare for pollination
- Fruit Set: Fertilized flower develops into fruit

Light Color Impact:

- Signal to begin flowering often based on length of day/ sunlight availability (photo periodic)
- Plant's highest light needs are generally during this phase, leading towards sugar and ethylene development
- Red and far right red shade colors can trigger flowering and increase amount and size of flowers/ fruit

Role of Shade Cloth, Greenhouse Curtain, Polyfilm:

- Prevent sunburn and provide cooling in very warm climates or temporary cover at specific times of day
- Mechanism to modify light colors: Even balance of red and blue can prevent shade avoidance behaviors (stem elongation)
- Crop protection from weather or pests
- Insect netting use can keep pollinators close to crops and pests away
- Greenhouse curtain or Polyfilm with diffusion above 30% can get light to various canopy levels

Role of Light:

- For crops that flower, red and far red light stimulate flowering and fruit production
- Most crops need at least moderate light to flower; Poinsettias flower after daily light declines

Specific Crops and their Textiles:

- Allow plant to see daily light cycles
- Peppers: ≥ 50% shade or ≤ 50% transmission to reduce light in areas with long days
- Tomato: protect from animals and weather

Germination/ Seedling	Seedling	Vegetative Growth	Flowering	Ripening

What's Occurring?

- Enhancement of color, scent, flavor and texture
- Further development of flavanoids
- Increase in sugar content

Role of light: Completion of the development cycle

- Enhance colors, flavors and nutrition
- Blue Light supports synthesis of anthocyanin pigments responsible for the red, blue, and purple colors in many fruits

Role of Shade Cloth:

- Keep plants cool/avoid sunburn with low shade percentage or white

Germination/ Seedling	Seedling	Vegetative Growth	Flowering	Ripening

Percent Shade Recommendation by Crop Zone and Plant Type

	Zone	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9	Zone 10	Zone 11
	Average DLI*	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60
Plant Type	Plant	Ideal DLI*										
Vegetables	Beets	12-20	N/A	N/A	N/A	20%	45%	50%	55%	60%	65%	70%	70%
	Broccoli	15-35	N/A	N/A	N/A	N/A	N/A	20%	20%	25%	35%	40%	45%
	Lettuce	14-16	N/A	N/A	N/A	20%	40%	50%	55%	65%	65%	70%	75%
	Spinach	12-18	N/A	N/A	N/A	20%	40%	50%	60%	65%	65%	70%	75%
Fruit	Bell peppers	20-30	N/A	N/A	N/A	N/A	N/A	20%	30%	40%	45%	50%	55%
	Bell peppers (seedling)	8-18	N/A	N/A	20%	45%	50%	55%	60%	65%	65%	70%	75%
	Blackberries	8-14	N/A	N/A	20%	40%	50%	60%	65%	70%	75%	80%	85%
	Cucumbers (seedlings)	5-15	N/A	N/A	N/A	30%	60%	65%	75%	75%	80%	80%	80%
	Cucumbers	20-30	N/A	N/A	N/A	N/A	N/A	20%	30%	40%	45%	50%	55%
	Oranges	22-30	N/A	N/A	N/A	N/A	N/A	20%	30%	40%	50%	50%	55%
	Peaches	8-14	N/A	N/A	35%	40%	50%	60%	65%	70%	75%	75%	80%
	Strawberries	17-28	N/A	N/A	N/A	N/A	N/A	25%	35%	45%	50%	55%	60%
Flowers	Chrysanthemums	10-14	N/A	N/A	35%	50%	60%	65%	70%	75%	75%	80%	80%
	Lilies	4-14	N/A	20%	45%	60%	65%	75%	80%	80%	80%	85%	85%
	Orchids (high light)	8-18	N/A	N/A	20%	40%	50%	60%	65%	70%	75%	80%	85%
	Orchids (low light)	4-6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Orchids (mid light)	4-8	N/A	40%	60%	70%	75%	80%	80%	85%	85%	90%	90%
	Petunias	16-18	N/A	N/A	N/A	15%	30%	40%	50%	55%	60%	65%	70%
	Roses	18-22	N/A	N/A	N/A	N/A	20%	35%	40%	50%	55%	60%	65%
Cannabis	Seedlings	12-16	N/A	N/A	20%	30%	45%	55%	60%	65%	70%	70%	75%
	Vegetative	20-45	N/A	N/A	N/A	N/A	N/A	N/A	N/A	20%	25%	35%	40%
	Flowering	30-40	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A%	20%	30%	35%

* DLI (Daily Light Integral) is the measure of how much light a given location recieves in 1 day

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References

- Stamps, Robert H., 2009 'Use of Colored Shade Netting in Horticulature'
- American Society for Horticultural Science (Apr 2009 pages 239-241) Accessed Dec 2023 from https://journals.ashs.org/hortsci/view/journals/hortsci/44/2/article-p239.xml
- Chen Shi and Hongtau Liu, 2021; 'How plants protect themselves from ultraviolet-B radiation stress' Plant Physiology ' (May 2021 pages 1096-1103; Accessed Dec 2023 from National Library of Medicine
- Park, Yujin and Runkle, Eric, 2017 'Far Red Radiation Promotes Growth of Seedlings by Increasing Leaf Expansion and Whole Plant Assimilation', Environmental and Experimental Botany (Volume 155, Nov 2018 pages 206-216) https://www.sciencedirect.com/science/article/abs/pii/S009884721830755X
- Use of green light: Michigan study: https://www.canr.msu.edu/news/green_light_is_it_important_for_plant_growth#:~:text=Another%20potential%20advantage%20of%20green,loss%20of%20the%20lower%20leaves.
- 'Light quality characterization under climate screens and shade nets for controlled-environment agriculture https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6016941/
- https://plantelys.dk/en/how-many-%C2%B5mol-does-my-plant-need-to-thrive/

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