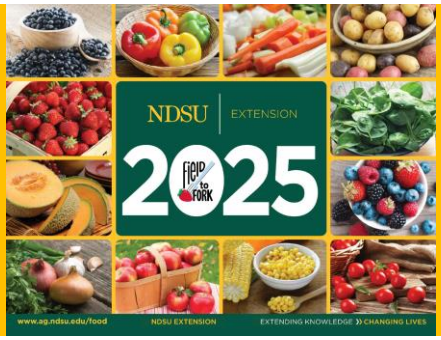
EXTENDING KNOWLEDGE ›› CHANGING LIVES

NDSU | EXTENSION



Upcoming Webinars

- **March 19 - Pickling Safety**
  - Cindy Brison, University of Nebraska Extension educator
- **March 26 - Tips and Tricks for Vegetable Production**
  - Susie Thompson, NDSU Department of Plant Sciences associate professor and potato breeder

NDSU EXTENSION

NDSU EXTENSION

- **Please complete the short online survey** that will be emailed to you after today's webinar. It will take just a couple minutes!
- Be sure to sign up for an opportunity to win a prize in the drawing. After submitting the survey, a form to fill out with your name/address will appear.

Acknowledgement: This project was supported by the U.S. Department of Agriculture's (USDA) Agricultural Marketing Service through SCBG24-246. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the USDA.

NDSU EXTENSION

March 12

The Science Behind Indoor Plant Lighting

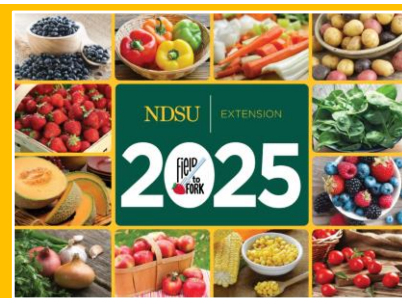
Esther McGinnis, NDSU Extension Horticulturist and Associate Professor

NDSU EXTENSION

Nondiscrimination Statement

NDSU does not discriminate in its programs and activities on the basis of age, color, gender expression/identity, genetic information, marital status, national origin, participation in lawful off-campus activity, physical or mental disability, pregnancy, public assistance status, race, religion, sex, sexual orientation, spousal relationship to current employee, or veteran status, as applicable. Direct inquiries to Vice Provost, Title IX/ADA Coordinator, Old Main 100, 701-231-7708, ndsu.eoaa@ndsu.edu. This publication will be made available in alternative formats for people with disabilities upon request, 701-231-7881.

NDSU | EXTENSION



NDSU | EXTENSION

What do I need to know to buy a LED grow light?

SMD

PPFD

COB

PAR

DLI

It's complicated

Kelvin

Lumens

Photoperiod

µmol/m²/s

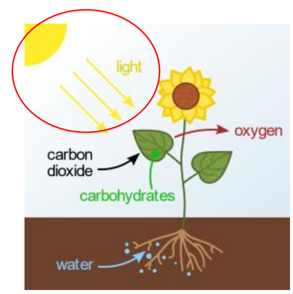
Wavelengths

NDSU | EXTENSION

Photosynthesis

Inputs
*H_2O
*CO_2

Outputs
*Carbohydrates
*O_2

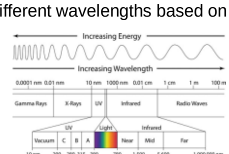


NDSU | EXTENSION

At09kg, Wattcle, NefronusAt09kg: originalWattcle: vector graphicsNefronus: redoing the vector graphics, CC BY-SA 4.0 <https://creativecommons.org/licenses/by-sa/4.0>, via Wikimedia Commons

Tiny taste of physics

- Light acts like particles AND like waves
  - Particles of light are called photons; quantity
  - We can see different wavelengths based on their color; quality



NDSU | EXTENSION

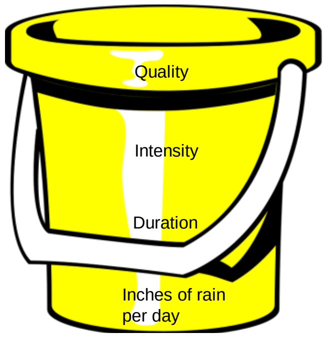
Rosenfeld Media, Flickr, CC by 2.0

Three Aspects of Light

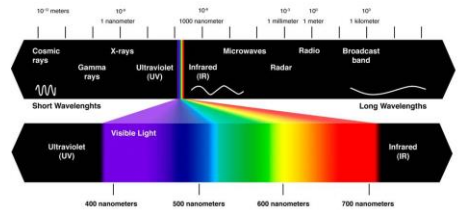
- Light quality: wavelengths of light
- Light quantity: intensity of light
- Light duration: hours/day

Daily Light Integral (DLI)

NDSU | EXTENSION



Light Quality--Wavelengths



NDSU EXTENSION

Plant Wavelengths

More energy

Light	Wavelength (nm)	Function in Plants
Ultraviolet	100-400	Initiate plant defense responses
Blue light	400-500	Photosynthesis (more efficient)
Green light	500-600	Photosynthesis (less efficient)
Red light	600-700	Photosynthesis (more efficient)
Far red (barely visible)	700-800	Shade avoidance; a little helps plant growth
Infrared	800-2500	Heat
Thermal (longwave)	2500+	Heat

Less energy

PAR: photosynthetically active range is from 400 to 700 nm

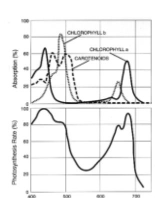
Wavelengths Affect Plant Growth

- Only blue light (400-500 nm): really short plants with small leaves and good roots
- Only red light (600-700 nm): taller plants with bigger leaves, not many branches; helps with flowering/fruiting
- Only far red (700-800 nm): stretched plants
- Blue + Red: compact and well-branched
  - Good root system
  - Helps plants with colored leaves color up

NDSU EXTENSION

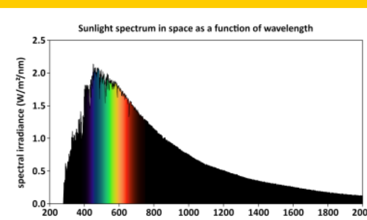
Important Term!

- PAR = Photosynthetically Active Radiation
  - Measure of "useful light" to the plant
  - Useful light is between 400 and 700 nm
  - Measure with a spectrometer



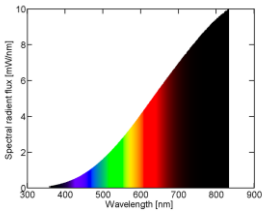
NDSU EXTENSION

Sun's Light Spectrum



NDSU EXTENSION

Incandescent Light Spectrum

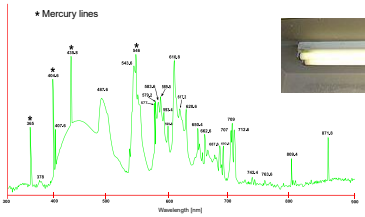


*Rich in far red
*Low PAR
*Mostly heat
*Energy inefficient
*Short bulb life

Fluorescent Lights v. Incandescent

- More energy efficient
- Less heat; can be placed close to plants
  - Except CFLs
- Bulbs last longer
- More PAR
- Bulbs contain mercury; hazardous waste

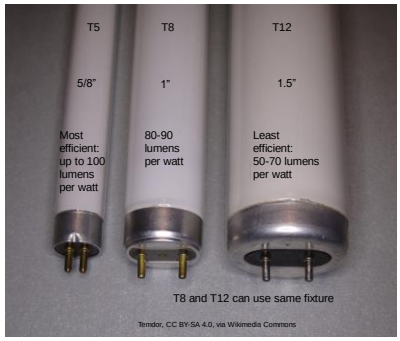
Fluorescent T8 Bulb (daylight)



Spectrum from a 48" Philips F32T8 natural sunshine fluorescent light

Fluorescent tube bulbs

T5HO, full spectrum



Fluorescent Tubes Are Still Useful Plant Lights

- Couple "daylight tubes"
- OR mix one cool white and one warm white
- Place them 3-6 inches above seedlings
- Make sure to raise as they grow
- Replace bulbs every year or two
- Uses more energy than LED

LEDs: Light emitting diodes

- Very energy efficient
- Less heat
- Long bulb life
- $$$
- High intensity
- Can be hung further away from the plants
- Can emit a narrow spectrum of wavelengths

Household White LED???

*Optimized for human eye; not PAR

First Generation LED Plant Lights

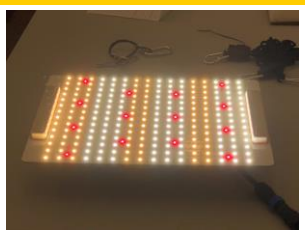
Blue and red lights

BLURPLE!

*OK if using in greenhouse as supplemental light
*Hard on the eyes
*Plants look black
*Outdated

NASA, CC-CC0-1.0

Next Generation LEDs: Warm White



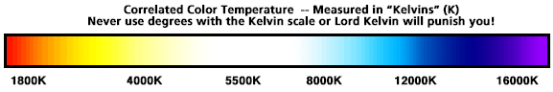
3000K, 5000K, 660 nm, 730 nm

High intensity

Looks white from the side

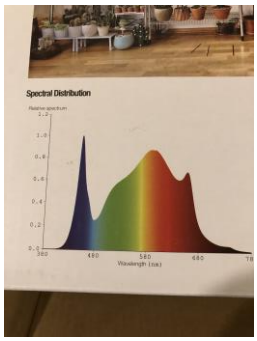
Not endorsing this product

Kelvin scale—less helpful

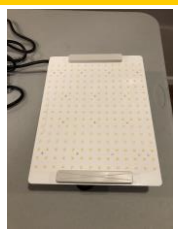


*More for humans
*Approximate color of light
*Lower numbers = warmer, redder light
*Higher numbers = cooler, bluer light

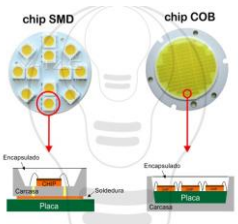
Deb Krolls, CC SA 3.0



Surface Mounted Device (SMD LED)

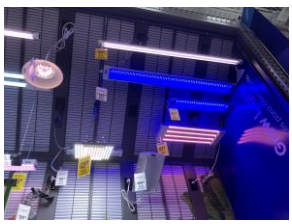


Avoid COB LEDs



LED Tube Grow Lights

- Plastic
- *No mercury
- *Look for “plug and play” bulbs if want to use fluorescent fixtures
- *Look for grow lights
  - Flower/fruit
  - Greens/seeds



LIGHT QUANTITY/INTENSITY

Plants Need Different Quantities of Light

- Low light houseplants—lower amount
- Quality seedlings need a moderately high amount
- Mature fruiting plants (tomatoes and peppers) need HUGE amounts of light

We Can Measure Light Quantity

- Count the photons!
- Photosynthetic photon flux density (PPFD)
  - Amount of PAR that lands on a square meter per second
  - Micromoles (μ) (of photons) per meter squared per second
  - mmol/m^2/s

Phone Apps

*Photone

*Less accurate than expensive light meters

PPFD Estimates (Dr. Neil Mattson)

Outdoor

- Sunlight—2000 mmol/m^2/s
- Shade—400 mmol/m^2/s
- Cloudy winter day—50 mmol/m^2/s

Indoors

- South facing window—100 mmol
- Office with light/window—20 mmol
- Night with table lamp—4 mmol

Choosing Lighting

Supplemental Lighting

- Growing near window(s)
- Choice of light is not as crucial
- Okay to buy light in the $25-50

Sole Source Lighting

- Basement/lighting tent
- Light choice is critical
- Research light quantity range for your crop(s)

Proximity to Plants Matters (Inverse square)

- At one foot: light gives off 200 mmol/m^2/s
- At two feet: light gives off 50 mmol/m^2/s
- At three feet: light gives off 22 mmol/m^2/s

LIGHT DURATION

Light Duration and Flowering

- Photoperiod: number of hours of light per day
- Some plants are photoperiodic: # hours of light can stimulate flowering
- Flowering
  - Short Day Plants: 8 hours of light/16 hours of darkness

Light Duration (Photoperiod) Affects Total Quantity of Light

- Don't want vegetable seedlings to flower
- Most are day neutral
- Long hours of lighting can offset low intensity lighting

Photoperiod + Light Quantity

- Several T8 fluorescent tube lights four inches above your crop; may need to leave it on for 16-18 hours to get enough light
- High output, expensive LED lamp—same quantity of light in 8 hours
- Cheap LED—might need to leave the lamp on for 34 hours!

In general . . .

- Have lighting on for 16 hours per day for vegetable starts
- Plants need to rest
- Lettuce and spinach are a little more sensitive (<14 hrs)
- Use a light timer

BRINGING IT HOME: DAILY LIGHT INTEGRAL

Three Aspects of Light

- Light quality: wavelengths of light
- Light quantity: intensity of light
- Light duration: hours/day

Daily Light Integral (DLI)

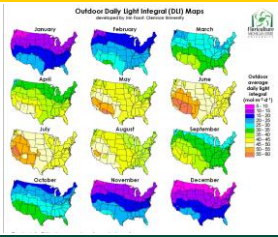
NDSU EXTENSION

Daily Light Integral (DLI)

- Takes into account all three factors of light
- Amount of useful light (PAR) delivered over a square meter (PPFD) per 24 hour day (photoperiod)
- DLI = PPFD x Hrs. x 0.0036
- DLI measurement --mol/m^2/d

NDSU EXTENSION

Sun is our best source for light quantity . . . But it varies by season



NDSU EXTENSION

BUT HOW MUCH DLI DO COMMON PLANTS NEED?

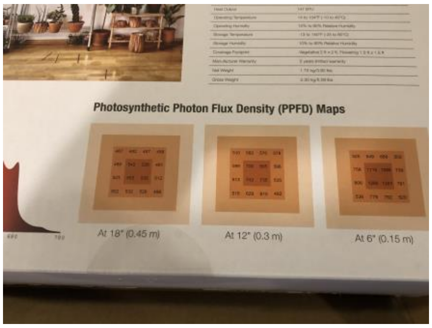
NDSU EXTENSION

Plant	PPFD (mmol/m^2/s)	DLI (mol/m^2/d)
African violets	70-300	4-14
Basil	220-500	12-26
Cucumbers (fruit)	300-600	20-30
Cucumber (seedlings)	100-300	5-15
Lettuce (Butterhead)	250-350	14-16
Lemon tree	300-600	21-28
Peace lily	20-40	4-14
Peppers (fruit)	300-600	20-30
Peppers (seedling)	150-350	8-18
Other vegetable seedlings (early stage)	70-150	6-12
Succulents	500-2000	30-50
Tomatoes (fruit)	350-800	20-30
Tomatoes (seedlings)	150-350	8-18

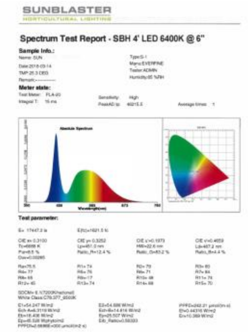
DLI (mol/m^2/day) for High Quality Plants

PPFD (mmol/m^2/s)	4 hrs.	8 hrs.	12 hrs.	16 hrs.	
50 mmol/m^2/s	0.7	1.4	2.2	2.9	Ok for supplemental
100 mmol/m^2/s	1.4	2.9	4.3	5.8 (vegetable seedlings)	
200 mmol/m^2/s	2.8	5.8 (vegetable seedlings)	8.6	11.6 (tomato seedlings)	Great for seedlings
500 mmol/m^2/s	7.0	14.5	21.5	29 (tomato to fruiting)	Fruiting

NDSU EXTENSION

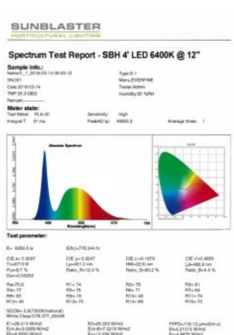


Overkill for seedlings
Great for succulents



6" above the plants

PPFD = 242.21 mmol/m^2/s



12" above the plants

116.13 mmol/m^2/s

Need More and Better Information on Boxes

52 PPFD

Evaluate Plant Growth

- Problems if not enough light
  - Seedlings may be leggy
  - Leaning towards the light
  - Plants may not flower or set fruit
- Too close to the light
  - Scorched leaves
  - Bleached leaves
  - Abnormal leaf reddening
  - Excessively compact growth

by Unknown Author is licensed under

Conclusions

- What am I growing?
- Do I need supplemental lighting or sole source lighting?
- What is my budget? (short-term v. long-term)
- Research and choose lights that:
  - optimize the right wavelengths (PAR)
  - select light intensity (PPFD) appropriate for your plant material
  - look up DLI and calculate number of hours of light necessary
  - adjust based on plant responses