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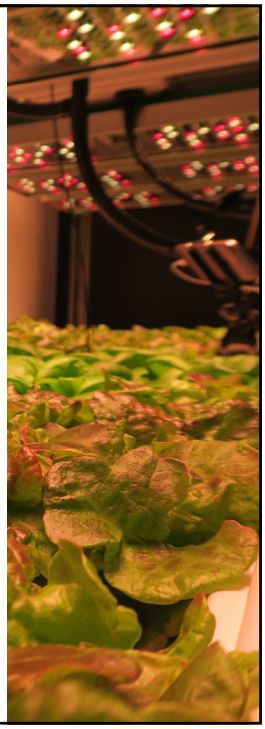
Crop-specific production: Lettuce



Nathan Kelly and Erik Runkle

Department of Horticulture
Michigan State University

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Getting started – lettuce variety selection

- Butterhead, bibb, oakleaf, romaine
- Red leaf vs. green leaf
- Days to maturity
- Market demand
- Conduct your own trials to identify top performers

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Process flow and automation

- Maximize space and energy use efficiency
- Minimize time between seed sow to harvest
- Automate tasks/systems such as:
  - Seed sow
  - Transplanting
  - Moving plants
  - Harvesting
  - Packaging
  - Environmental control
  - Nutrient solution and pH

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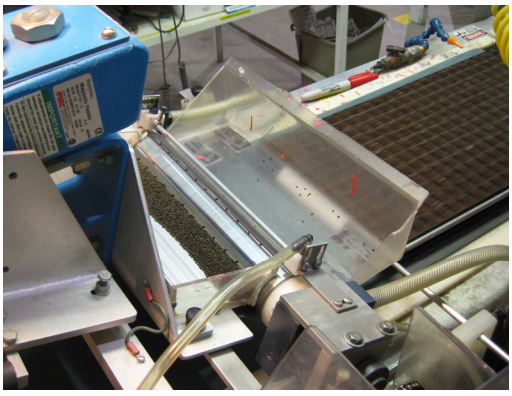
Sowing seeds

- Seed storage: 35-50 °F (2-10 °C)
- Automated seed sowing
- Separate germination environment
  - Continuous light to inhibit elongation of hypocotyls
  - Temperature of 66-70 °F (19-21 °C)
  - VPD of <0.3 kPa (>88% RH) until radicle emergence



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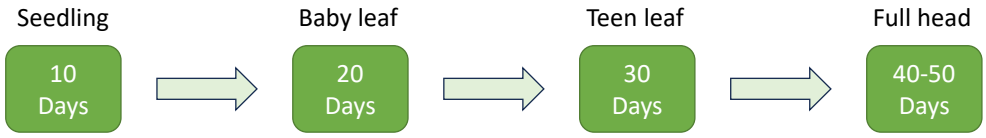
Planting density and time to harvest

- Planting density depends on age/target size at harvest
- 3 to 5 plants per square foot for head lettuce
- Approximate time to harvest depends on environmental factors, plant spacing, and plant maturity. For example:



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Substrate components and selection

- Rockwool
- Peat (± perlite)
- Coconut coir
- Phenolic foam
- Aeroponics

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Nutrient solution and management

- Hydroponics culture techniques provide nutrients through the water circulation system
- Begin with a properly designed nutrient formula based on water characteristics
- Adjustment of nutrients and/or pH may be needed during production cycle
- 150 ppm N from a hydroponics fertilizer
- pH of 5.5 – 6.0

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Contamination prevention

- Algae
  - Prevent nutrient solution exposure to light
  - Clean surfaces that come in contact with nutrient solution
- Monitor the introduction of new, young plants to prevent the spread of pests and pathogens
- Control points on entry
- Follow strict hygiene measures
  - Personal protective equipment (gowns, gloves, hair nets, shoe covers, etc.)
  - Wash hands
  - Sanitize equipment, growing surfaces, floors, etc.

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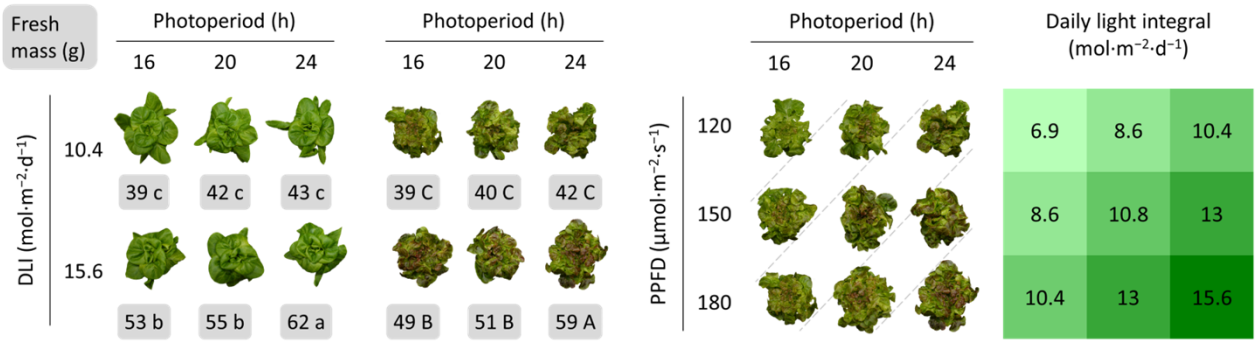
Kelly et al., 2022

Environmental conditions – light intensity

- Minimum DLI of 10 to 15 mol·m^{-2}·d^{-1}
- Lighting intensity of at least 150 µmol·m^{-2}·s^{-1}



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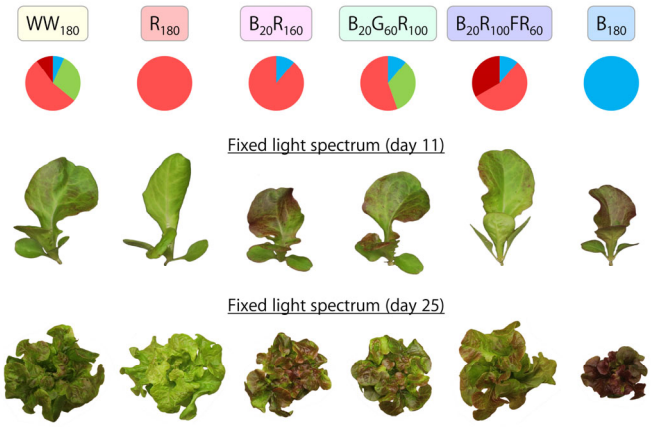
Environmental conditions – light quality

- The spectral distribution of a light source influences leaf size and color
- Generally, a high percentage of red and/or white light will produce the largest plants
- Also consider the efficacy (electrical efficiency) of a lighting fixture



Meng and Runkle, 2022

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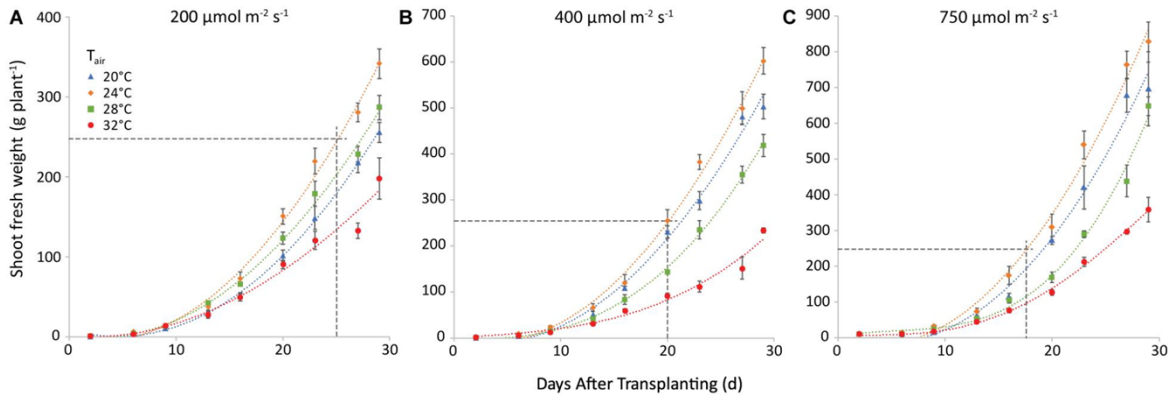
Air temperature

- 72-75 °F (22-24 °C) air temperature



Carotti et al., 2021

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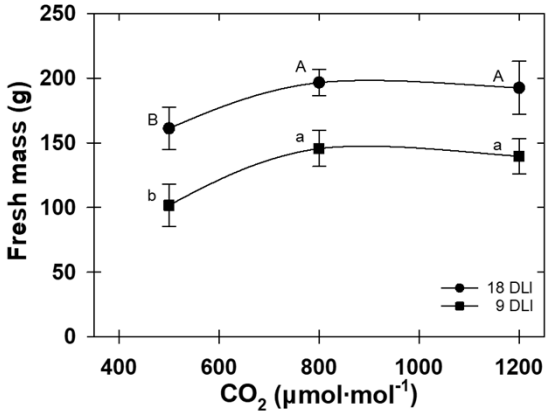
Carbon dioxide enrichment

- Photosynthetic rate increases with an increase in CO_2 concentration
- Ambient CO_2 level is around 420 ppm
- Supplementing CO_2 to 800 ppm increases lettuce growth, but light and temperature may have a greater effect



Tarr and Lopez (unpublished)

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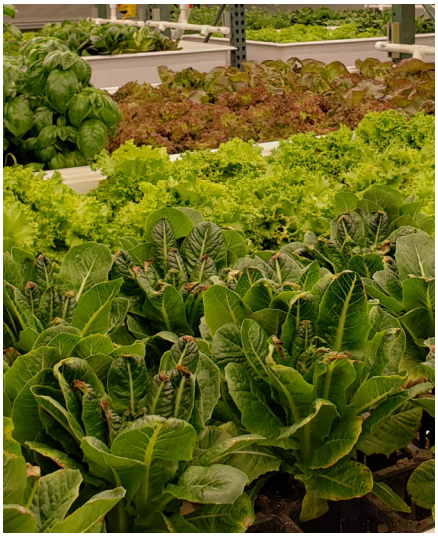
Humidity and VPD

- A low relative humidity (high vapor-pressure deficit) increases transpiration (water loss), while a high relative humidity decreases it
- High VPD can limit the spread of some pathogens and decrease tipburn occurrence
- A suggested VPD is at least 0.7 kPa [maximum 75% RH at 73°F (23 °C)]



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Air movement

- Air velocity and movement can regulate temperature uniformity, canopy VPD, and gas exchange in indoor farms
- A low air velocity can cause microclimates in indoor farms
- Increasing air flow can increase the VPD in the plant canopy, decrease tipburn occurrence, and increase photosynthetic and transpiration rates
- A suggested air velocity is 0.5-0.7 m/s

An example of an anemometer

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Harvesting

- Harvest age
- Manual vs. automated vs. combined harvests
  - Manual harvesting methods require much more labor but practically no capital costs
  - Automated harvesters have a very high capital cost but require very little labor

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Postharvest – packing and storage

- Clamshell packaging is common but expensive
- Separate, temperature-controlled postharvest storage area
  - 34-37 °F (1-3 °C) air temperature
  - Dark storage

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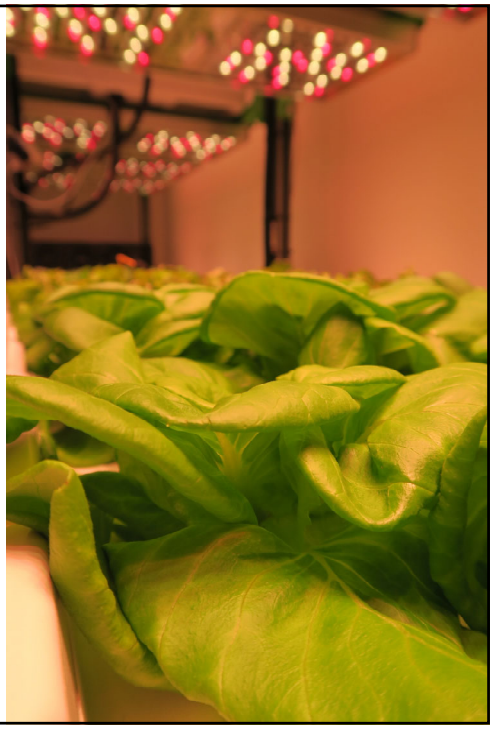

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