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2.1 Physiology of CEA Crops

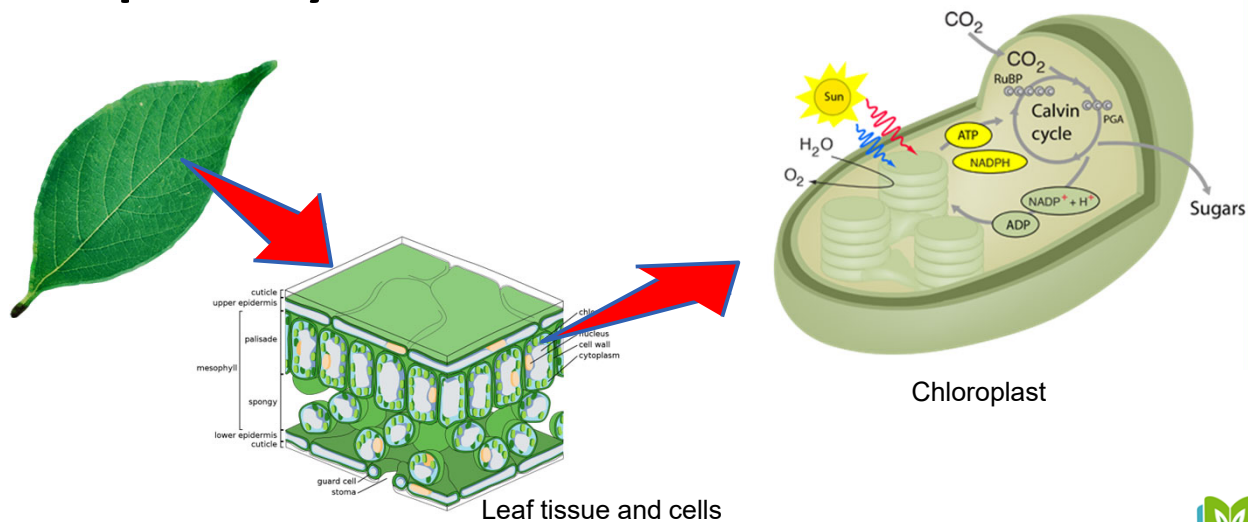
1. Light intensity, quality, and photoperiod

1.1 Plant leaf and canopy photosynthesis



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Site of photosynthesis



Illustrations by Wikimedia commons



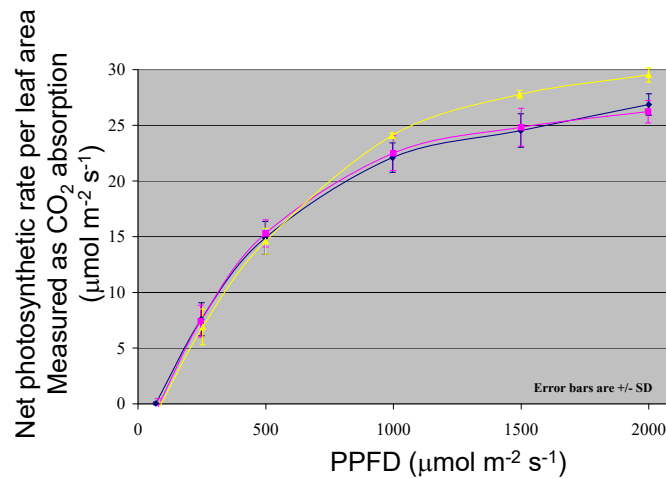
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Measuring leaf photosynthesis



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Typical leaf photosynthesis under varied PPFD

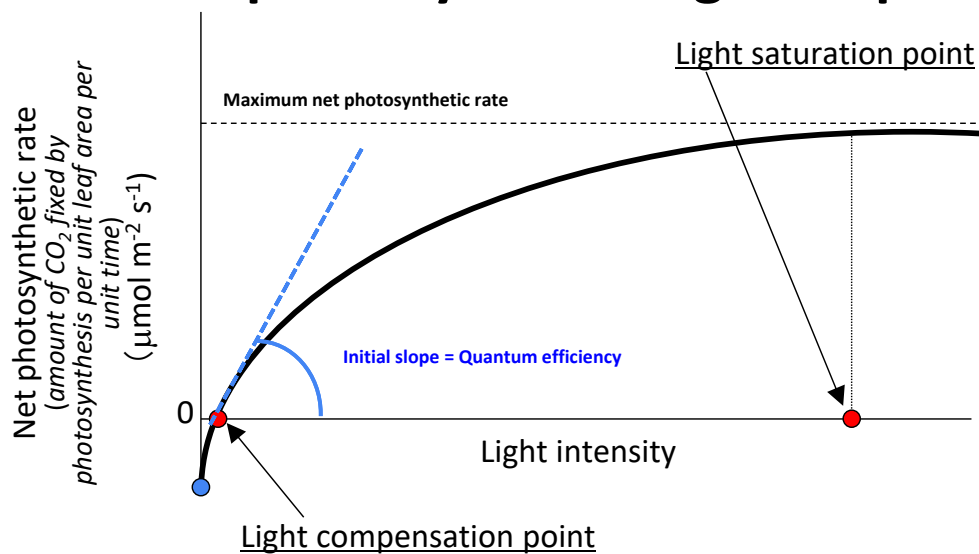


PPFD = photosynthetic photon flux density



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Parameters of photosynthetic light response



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Light saturation and compensation points

Greenhouse grown vegetable crops (as example)

- Light compensation point = 50-100 $\mu\text{mol m}^{-2} \text{s}^{-1}$ PPFD
- Light saturation point = 1000 – 1500 $\mu\text{mol m}^{-2} \text{s}^{-1}$ PPFD
- Max rate of photosynthesis (per leaf area): 10 – 20 $\mu\text{mol m}^{-2} \text{s}^{-1}$

Examples (reported by Hori, 1969)

Tomato

- Maximum rate = 20 $\mu\text{mol m}^{-2} \text{s}^{-1}$
- Light saturation point = 1000 $\mu\text{mol m}^{-2} \text{s}^{-1}$

Cucumber

- Maximum rate = 15 $\mu\text{mol m}^{-2} \text{s}^{-1}$
- Light saturation point = 1000 $\mu\text{mol m}^{-2} \text{s}^{-1}$



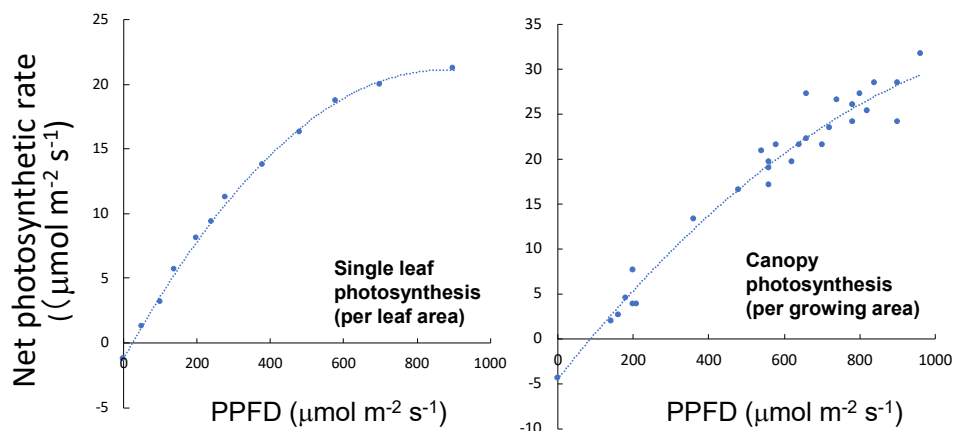
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Plant canopy



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Leaf photosynthesis vs. canopy photosynthesis

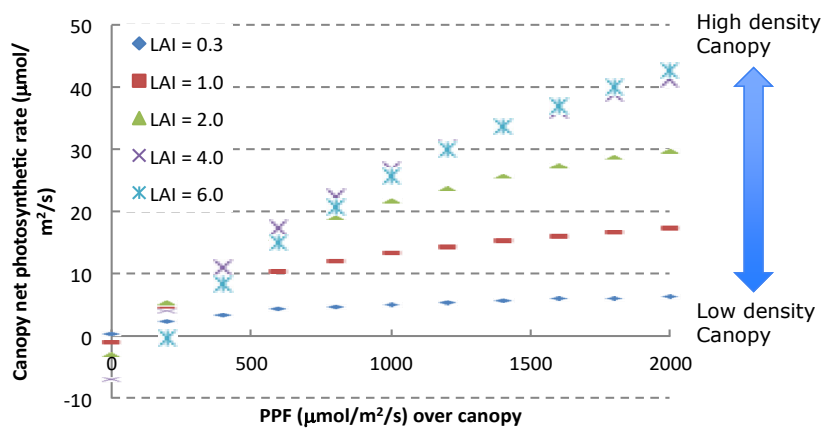


(after Jones 1992; Acock et al. 1978)



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Leaf area and canopy photosynthesis

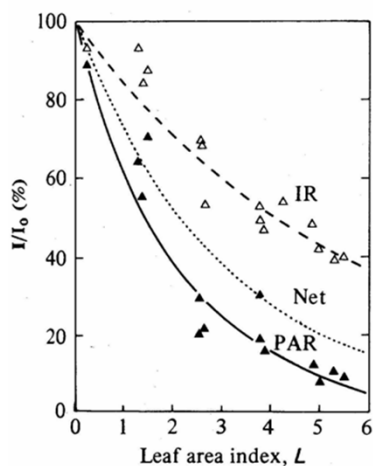


LAI (leaf area index) = total leaf area / ground surface area



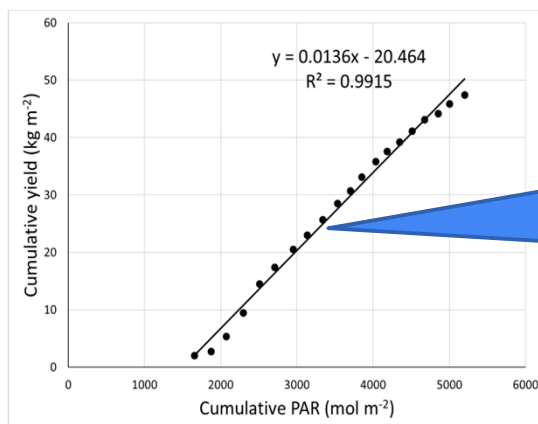
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Light highly absorbed by plants (such as PAR) reduces its intensity significantly as it penetrates deeper in the dense canopy



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Crop yield response (tomato)



"1% more light means
1% more yield"

Data source: Tomato (cv. Durinta) plants grown in UA CEAC greenhouses (Kubota et al., 2016)



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Crop DLI (daily light integral) recommendations

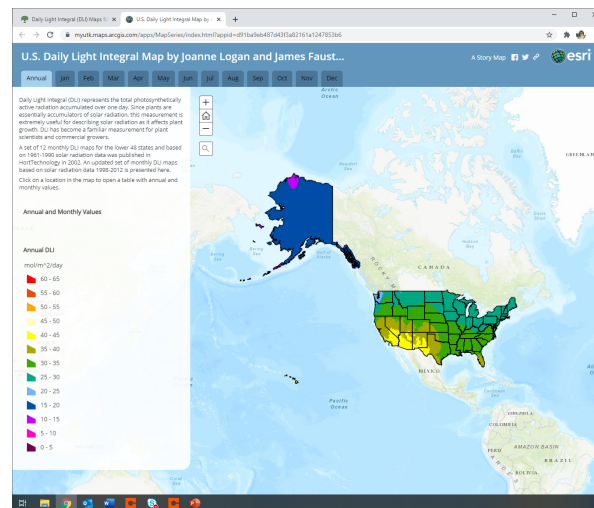
DLI	Seedlings 	Lettuce 	Cucumber 	Tomato 	Strawberry 
Minimum (mol/m ² /d)	12	12	12	12	12*
Optimal (mol/m ² /d)	15-20	<17	≥ 30	≥ 30	20-25?

Dorais et al. (2015, 2016), *Kubota et al., (2016)



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Daily Light Integral Maps for the U.S.



<https://endowment.org/dlimaps/>

Developed by
James Faust (Clemson University)
Joanne Logan (The University of
Tennessee)



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Supplemental lighting



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Summary

- **Leaf photosynthesis** of most greenhouse food crops has a light compensation point around $50\text{--}100 \mu\text{mol m}^{-2} \text{s}^{-1}$ PPFD and a light saturation point around $1000\text{--}1500 \mu\text{mol m}^{-2} \text{s}^{-1}$ PPFD
- **Canopy photosynthesis** does not saturate and shows a linear response to PPFD when LAI is high
- Because of the **linear response**, plant growth potential can be understood using DLI in greenhouse
- Crop yield increases linearly with increasing DLI. “**1% more light means 1% more yield**”
- When DLI does not meet the recommended minimum DLI ($12 \text{ mol m}^{-2} \text{d}^{-1}$ for most crops), **supplemental lighting** needs to be considered



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CEA
WORKS

THANK YOU