Cotyledon Competency in CEA: Light Response Curve Analysis across Emerging Mizuna Leaf Tissues

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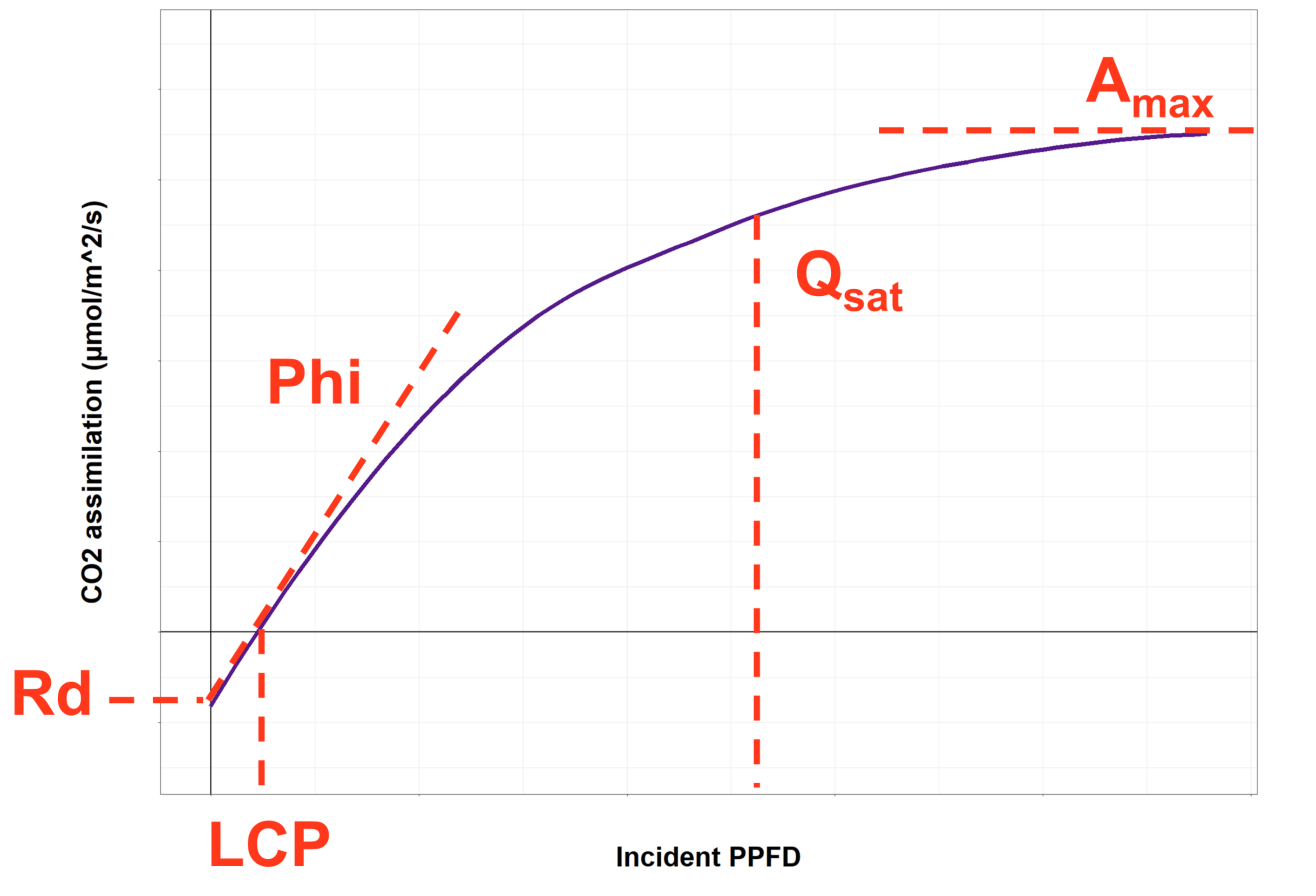
Background

- Costs associated with lighting account for 40-50% of overall vertical farm operational costs[1]. Interest in reducing costs associated with sole source LED lighting from academic institutions and indoor farms has led to the exploration of dynamic lighting, which can cater light intensity and spectrum to a crop's developmental stage.
- Quantifying plant photosynthetic competency can be accomplished by measuring rates of leaf carbon dioxide assimilation as a function of incident PPFD via a photosynthetic light response curve (LRC).



A_{max}
- Maximum photosynthetic rate at ~1200 PPFD

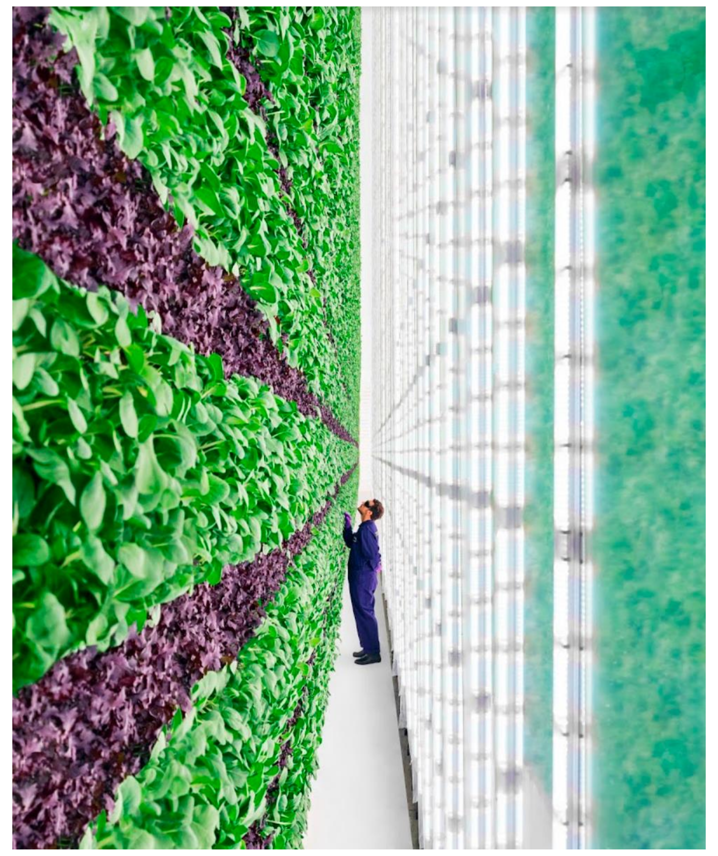
LCP
- Light compensation point - PPFD where CO2 assimilation rate = respiration rate

Phi
- Maximum quantum yield (slope of regression through 0,10,20,30,50 PPFD setpoints)

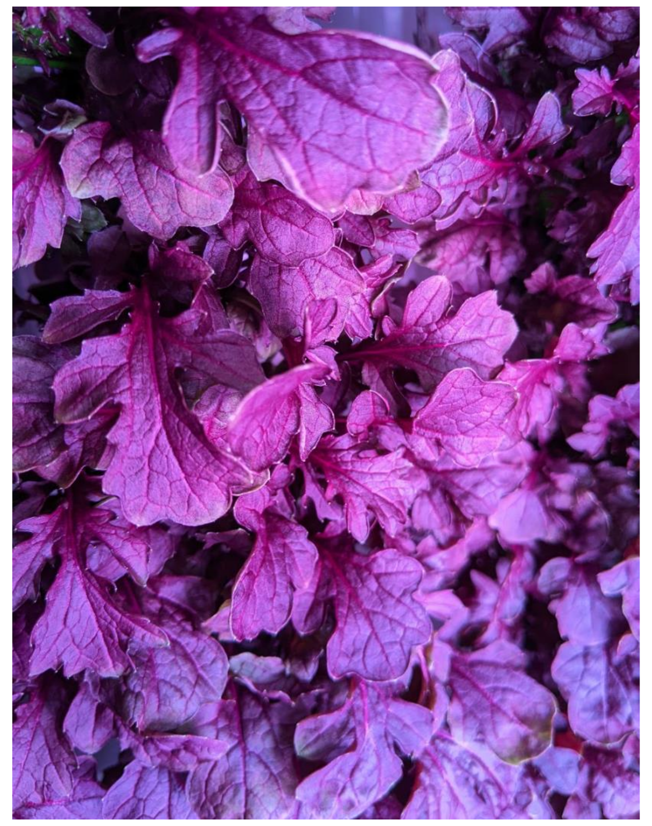
Q_{sat}
- Light intensity where the differential quantum yield[5] is = 20% of Phi

Rd
- Dark respiration rate. CO2 produced by leaf tissue during 4-minute dark acclimation.

Materials & Methods



Left: *Brassica* crops growing in our vertical production farm Tigris. **Right:** Infrared gas analyzer mounted for light response curve measurements (LI-6800, Li-Cor, Lincoln, NE).



Left: Primary and secondary *B. juncea* leaf tissues were measured ~2 weeks after seeding. **Right:** *B. juncea* cotyledons were measured ~1 week post-seeding.

Results

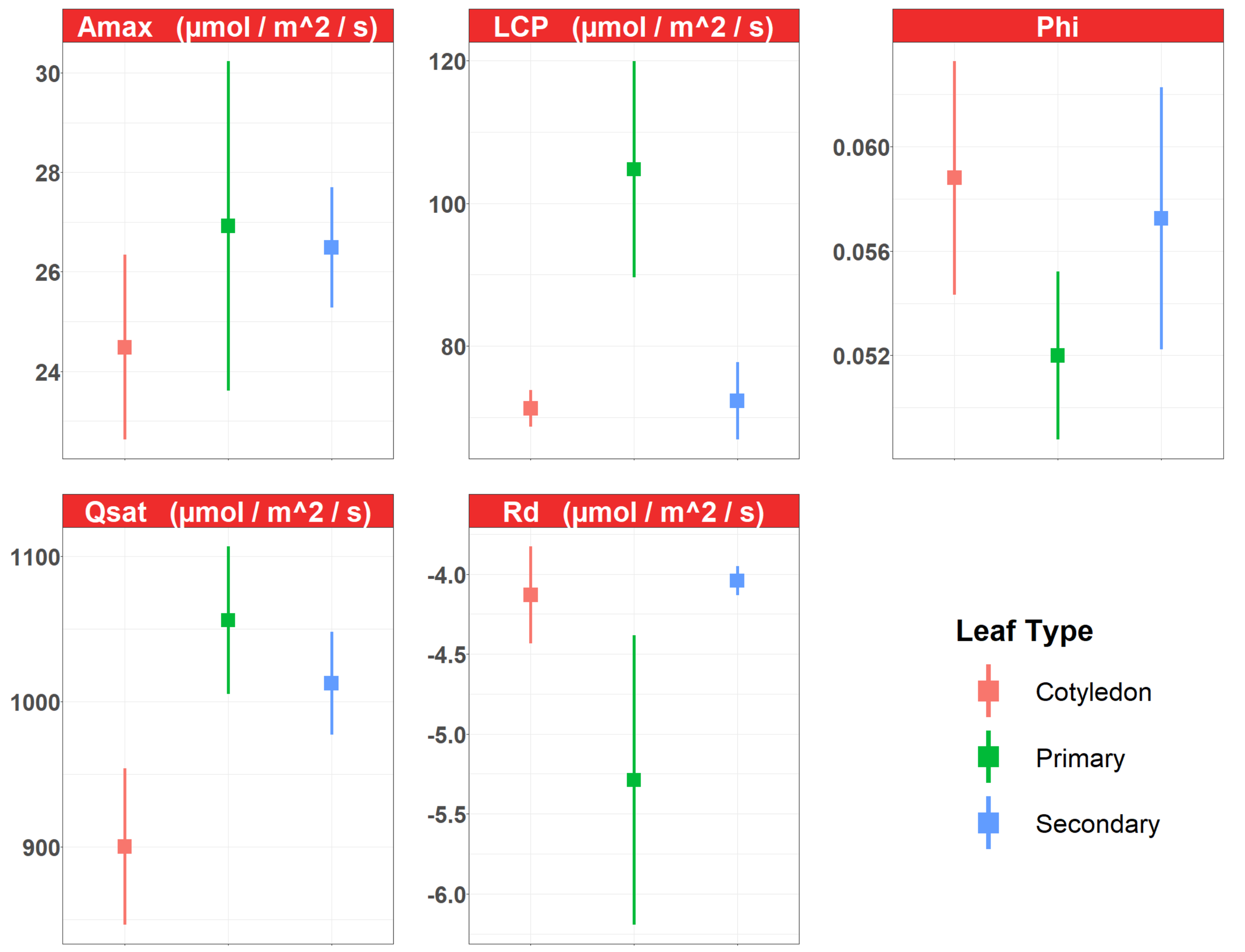


Figure 1. Points represent mean values +/- standard error of each calculated LRC parameter for 5 samples.

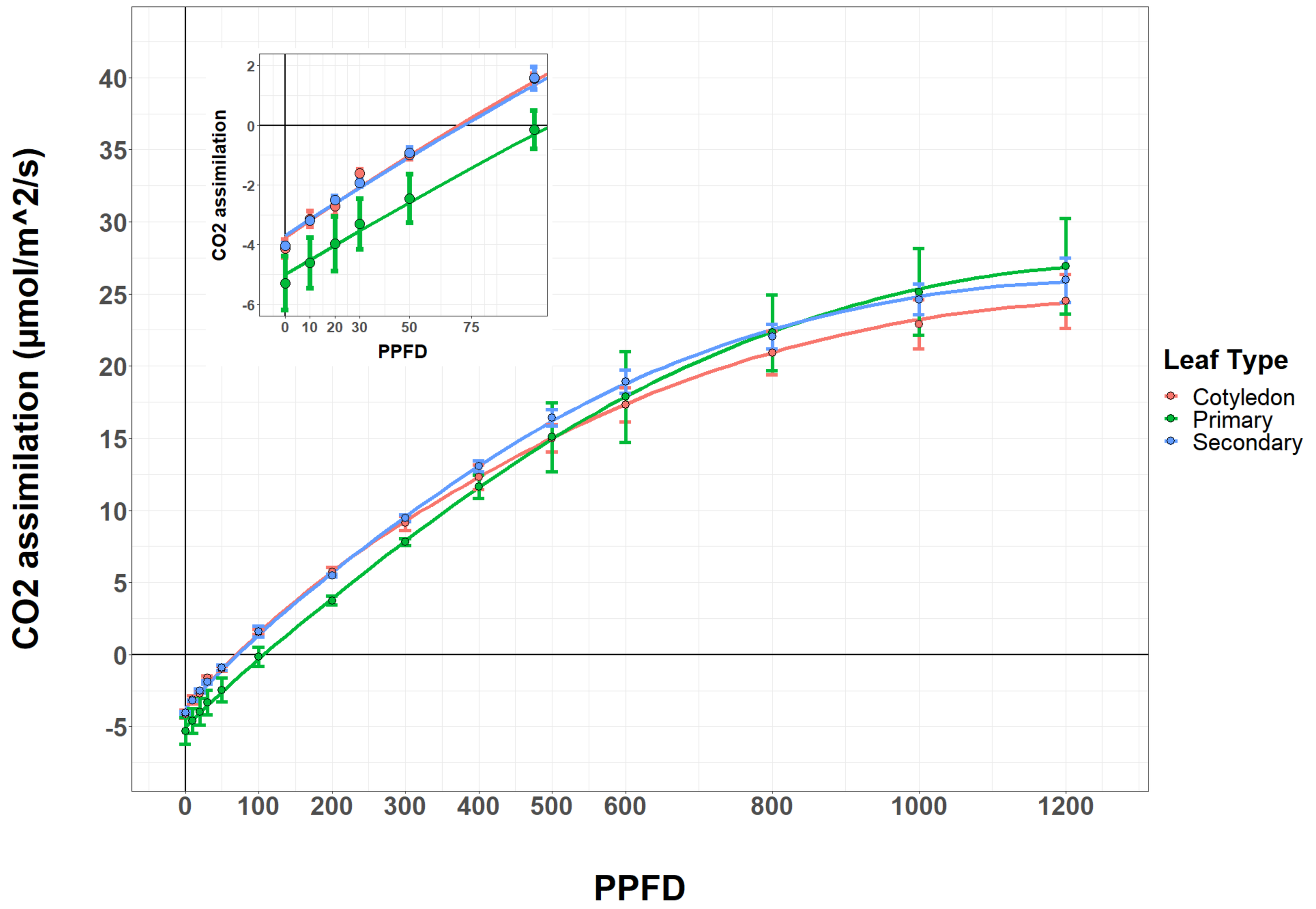


Figure 2. Points represent mean CO_2 assimilation values +/- standard error at each PPFD setpoint for 5 LRC samples. Inset plot shows first 6 PPFD setpoints of the LRC in higher resolution.

Discussion

- Recent work has demonstrated that photosynthesis isn't fully established in all primary leaf tissues – *Arabidopsis* cotyledons have well established photosynthetic capabilities while *Oryza sativa* leaf tissues only develop full photosynthetic capacity in successive emerging leaves beyond the coleoptile[4]. Based on light response curve performance metrics, our results indicate that Mizuna is likely a crop in which photosynthesis is well established in cotyledons and primary leaves.
- LRC analysis on Mizuna is challenging due to high anthocyanin content in outermost epidermal cells[3]. Anthocyanin pigments attenuate a sizeable portion of the incident blue and green light[2] which creates a more linear LRC response. Pigment-driven light attenuation likely contributes to low Phi values reported here, which in turn conflates values of LCP and Q_{sat}. LRC analysis on Mizuna and any highly pigmented leaf tissue should be interpreted with these issues in mind.

Future Work

- Identify critical photosynthetic competency points across crops to avoid over-supplying leaves with light at any given developmental stage.
- Explore light quality and environmental conditions that mitigate pigment biosynthesis in early developmental stages to increase light absorbance by leaf tissue.

References

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