Estimating Canopy Dark Respiration for Crop Models

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Crop Models

- Crop production is obtained from accurate estimates of daily carbon gain.
- Canopy gross photosynthesis (Pgross) can be estimated from biochemical models of photosynthesis using sun and shaded leaf portions and the amount of intercepted photosynthetically active radiation (PAR).
- In turn, canopy daily net carbon gain can be estimated from canopy daily gross photosynthesis when canopy dark respiration (Rd) is known.

Crop Respiration

- Respiration in living cells allows for the controlled oxidation of carbohydrates and other substances, so that much of the energy can be retained in a useable form, such as ATP.
- aerobic respiration – (glycolysis, the Krebs cycle, and the ETR).
    - **$6\ C_6H_{12}O_6 + 6\ O_2$ -> $6\ CO_2 + 6\ H_2O$ + energy**

Crop Respiration

- Respiration is difficult to estimate and several methods have been developed:
  - growth and maintenance
  - nitrogen content
- Measurements of respiration using $^{13}CO_2$ indicate that dark respiration is proportional to gross photosynthesis.

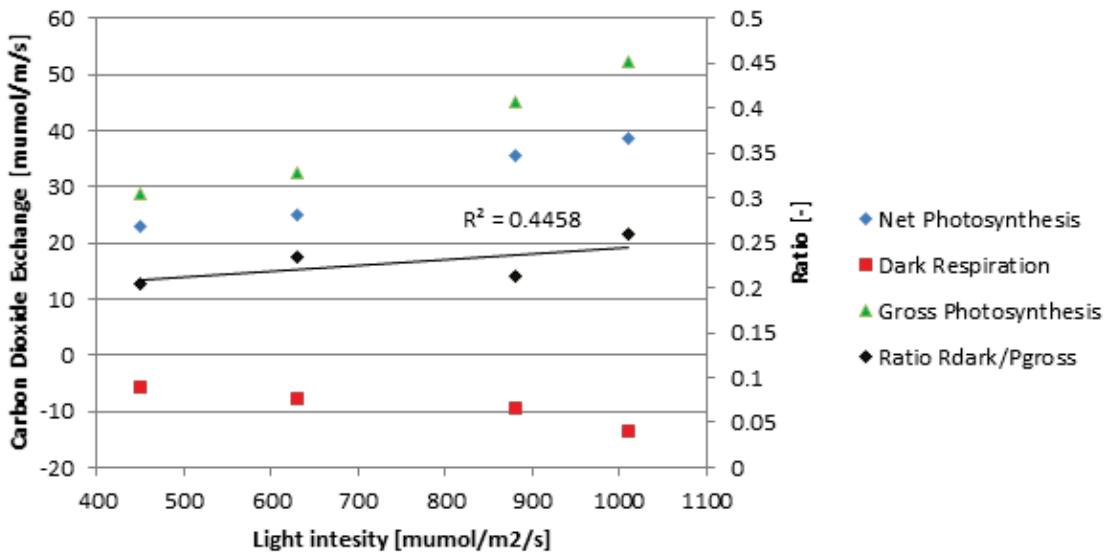
Empirical Approach: R_d/P_{gross} ratio

- Using a constant Rd/Pgross ratio can simplify crop models estimating canopy-scale daily carbon gain.

- Dark respiration has been assumed to be a constant fraction of Pgross (Monteith 1977):
    - $R_d / P_{gross} = 0.4$
- Pnet = 0.6*Pgross = 0.6*RUE*APAR
    - RUE = Radiation Use Efficiency
    - APAR = Absorbed PAR

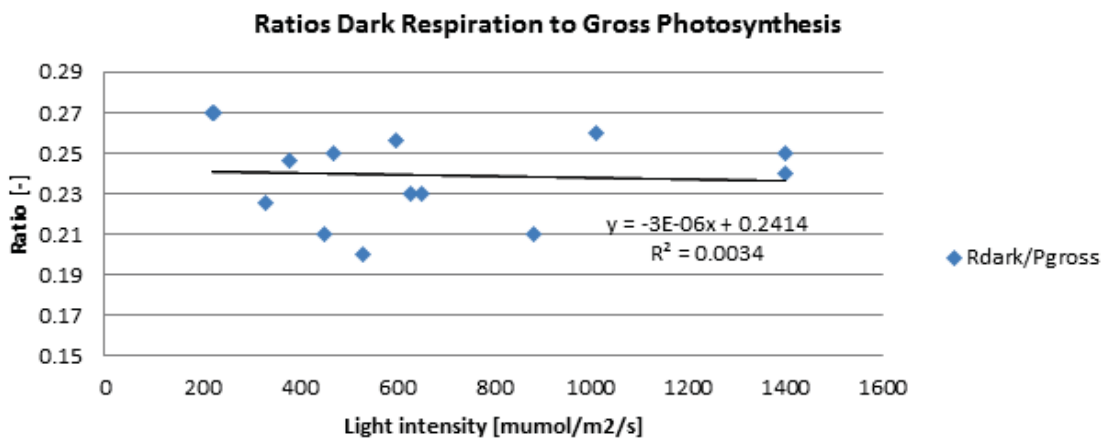
Does R_d/P_{gross} Vary with Light Intensity?

- The effect of light intensity (450, 630, 880, and 1010 µmol m^{-2} s^{-1}) on Rd/Pgross of pepper plants was measured at a constant CO_2 concentration.



Does [CO_2] affect Rd/Pgross ?

- Several datasets including high CO2 concentrations (330 to 1300 ppm) were analyzed: pepper (this study), wheat (Monje et al. 1998), tomato and lettuce (Frantz et al. 2005). A mean canopy level Rdark/Pgross is 0.242 for C3 plants and the ratio is independent of light intensity and CO2 concentration.



Conclusion

- A gas exchange system was used to measure the effect of increasing light levels on the canopy level ratio of respiration to gross photosynthesis.
- A mean canopy level Rdark/Pgross is 0.242 for C3 plants, which is roughly half of that observed for the leaf level.
- The Rdark/Pgross ratio was found to be independent of light intensity and CO2 concentration.
- These properties make the Rdark/Pgross a suitable approach for simplifying crop models for estimating daily carbon gain.