

## Estimating Carbon Use Efficiency, Growth Respiration, and Maintenance Respiration from Crop Gas Exchange Measurements

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## Why Photosynthesis?

- Plants contain approximately:
  - 40% C
  - 45% O
  - 6% H
- Leaf photosynthesis and plant growth or yield are poorly correlated

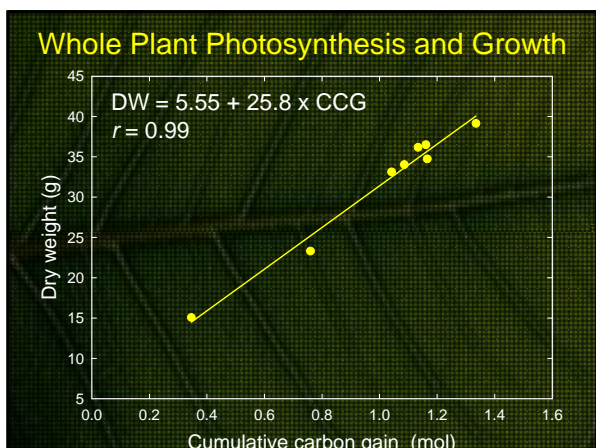
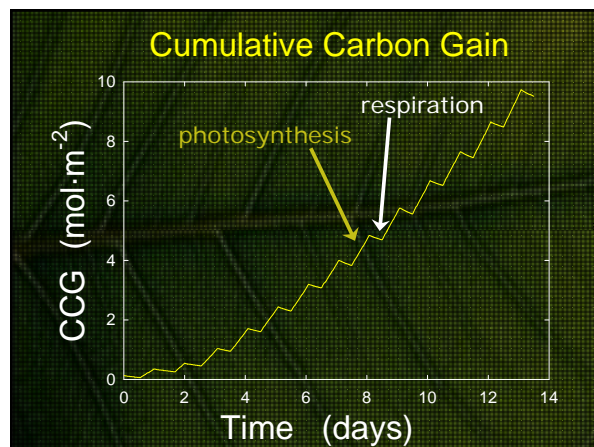
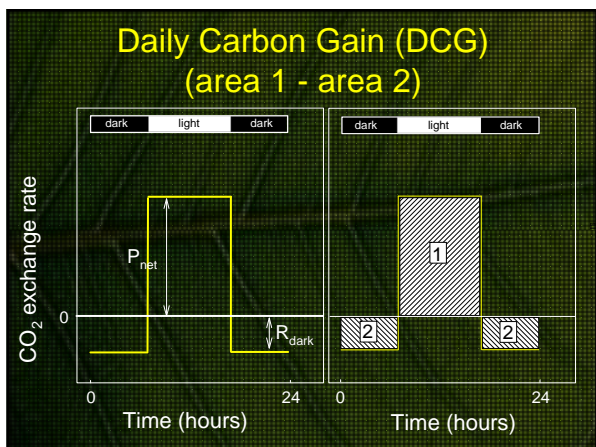
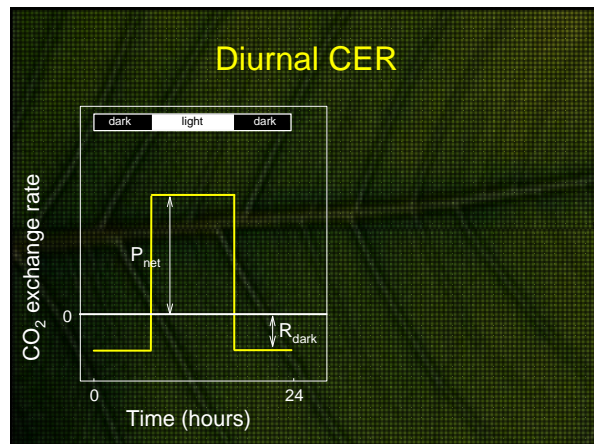
## Whole Crop Photosynthesis and Growth

- Direct measure of C incorporated into the plant
- With continuous measurements, net carbon gain can be determined
- Daily net carbon gain closely related to growth rate
- Cumulative carbon gain closely related to dry mass

Plexiglas chambers

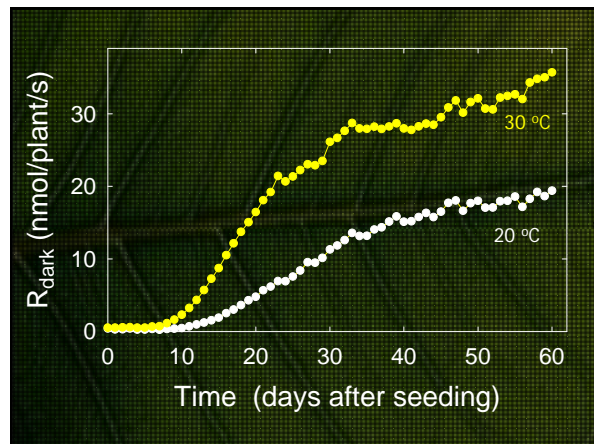
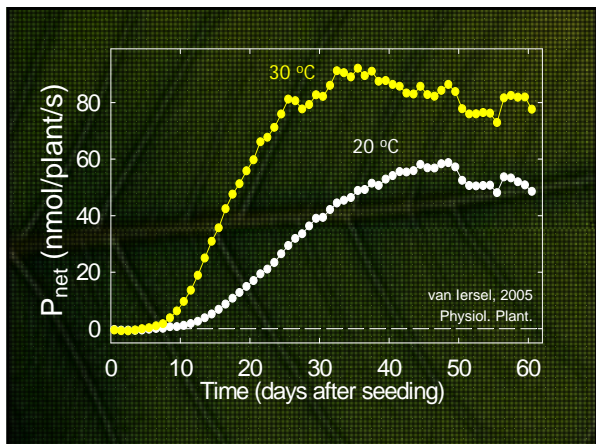






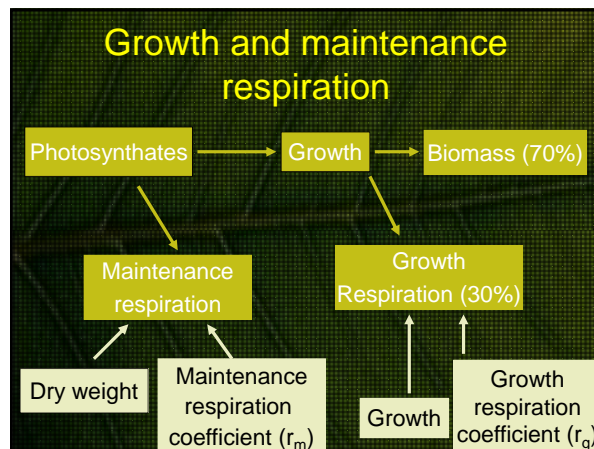
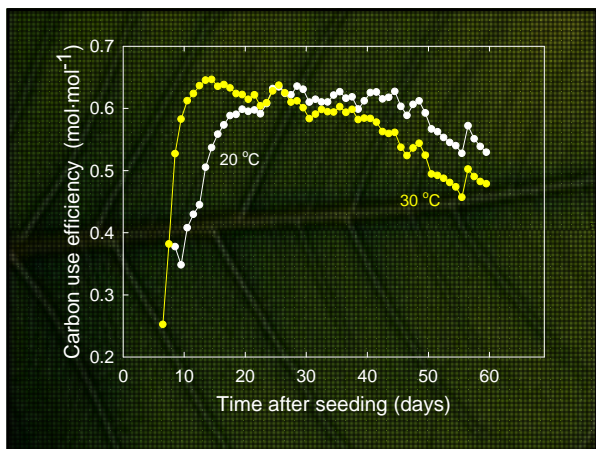
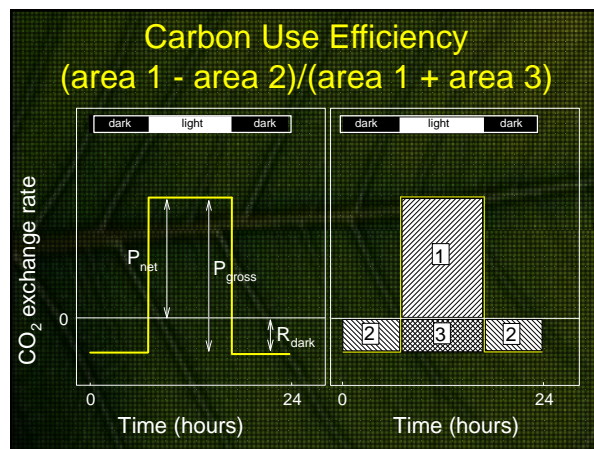
- ### Case Study
- Marigold grown at 20 or 30 °C
  - CO<sub>2</sub> exchange measured for 60 days





### Data Interpretation

- Carbon-use efficiency = 
$$\frac{\text{Net amount of carbon incorporated into the plant}}{\text{Gross amount of photosynthates produced}}$$





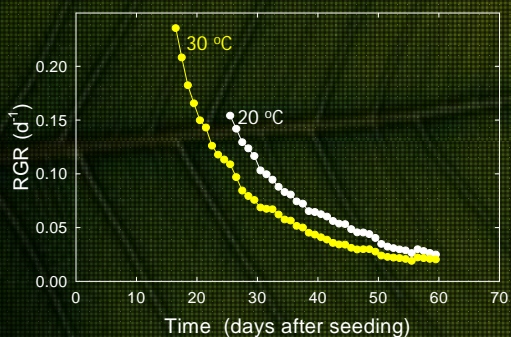
### Growth and maintenance respiration

- $R = R_m + R_g = r_m \times \text{weight} + r_g \times \text{growth}$
  - $R / \text{weight} = r_m + r_g \times \text{growth/weight}$   
 $= r_m + r_g \times \text{RGR}$
- IF  $r_m$  and  $r_g$  are constants, they can be estimated from linear regression

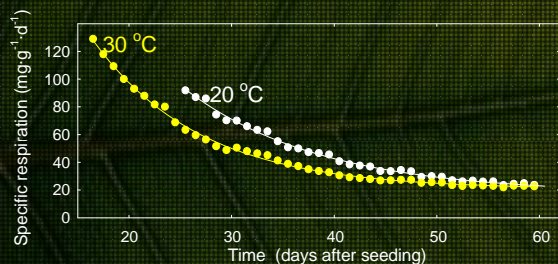
### Calculations

- Growth rate and plant dry weight were calculated from CO<sub>2</sub> exchange measurements and carbon content of the plants
- RGR (growth rate / dry weight) and specific respiration rate ( $R_{\text{dark}} / \text{dry weight}$ ) were calculated from these data

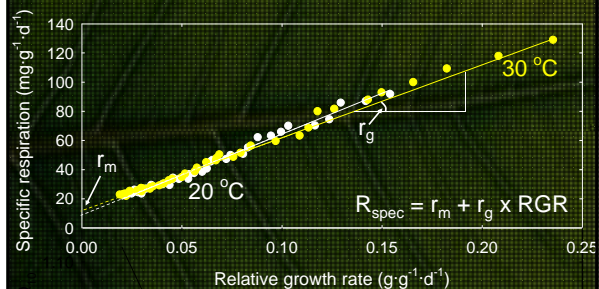
### Relative growth rate



### Growth and maintenance respiration



### Growth and maintenance respiration

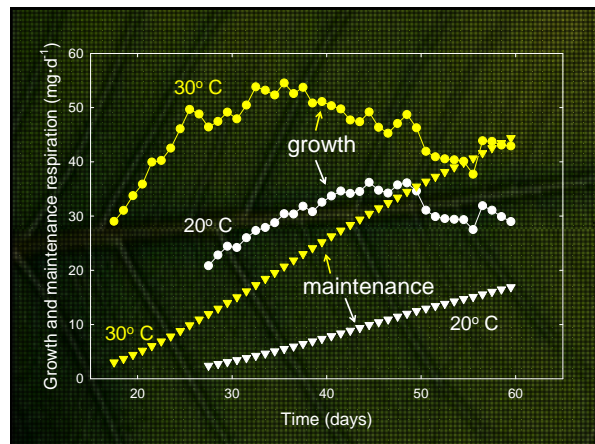
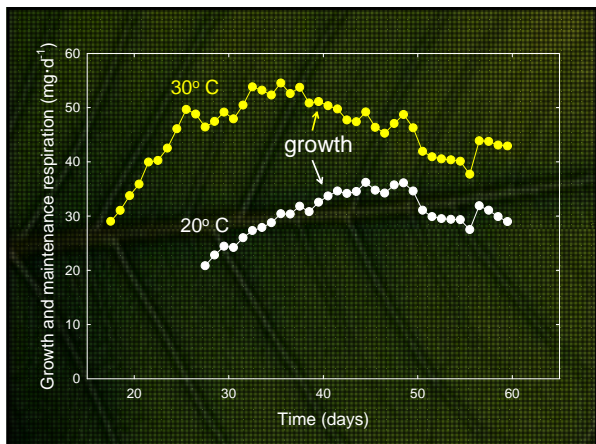


### Growth and maintenance respiration

Temperature	$m_r$ (mg·g <sup>-1</sup> ·d <sup>-1</sup> )	$g_r$ (g·g <sup>-1</sup> )
20 °C	8.4 ± 0.6	0.56 ± 0.01
30 °C	11.9 ± 0.5	0.50 ± 0.01
$Q_{10}$	1.42	0.89

Maintenance respiration =  $m_r \times \text{dry mass}$   
 Growth respiration =  $g_r \times \text{growth rate}$





- ### Conclusions
- Continuous whole plant CER gives:
    - Direct measure of growth
    - Physiological components of growth
      - Carbon use efficiency
      - growth respiration
      - maintenance respiration

