Temperature Effects on Photosynthesis, Growth Respiration, and Maintenance Respiration of Marigold

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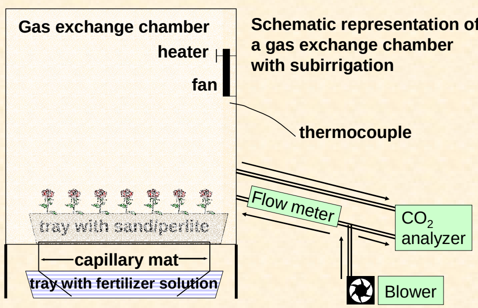
INTRODUCTION

Temperature greatly affects the carbon exchange rate and growth of plants. However, the exact method by which it affects growth is not always clear, because temperature affects both photosynthesis and respiration.

Respiration can be divided into two processes, growth (R_g) and maintenance respiration (R_m). R_g can be expressed as the growth respiration coefficient (r_g) × growth rate, while R_m is the maintenance respiration coefficient (r_m) × plant size. We hypothesized that an increase in temperature would increase r_m but not r_g.



Schematic representation of a gas exchange chamber with subirrigation

MATERIALS AND METHODS

CO_2 exchange rates of whole crops of marigolds grown at 20 or 30 °C were measured continuously from germination until flowering. Data were collected in an automated whole-plant gas exchange system (van Iersel and Bugbee, 2000).

Net photosynthesis (P_{net}) and dark respiration (R_{dark}) data were used to calculate net daily carbon gain (DCG) and cumulative carbon gain (CCG) of the plants throughout their life cycle. Relative growth rate was calculated as DCG/CCG.

DCG and CCG data also were used to determine the effect of temperature on r_g and r_m:

$$\mathbf{R_d = x_0{\times}DCG + x_1{\times}DCG{\times}T + x_2{\times}CCG + x_3{\times}CCG{\times}T}$$

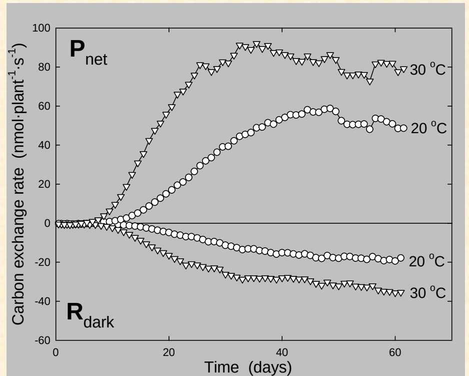
where Rd = total daily respiration, T = temperature, x_0 and x_1 are used to estimate r_g at a specific temperature, while x_2 and x_3 can be used to estimate r_m.

Carbon use efficiency (carbon incorporated into the plant divided by the carbon fixed in gross photosynthesis, mol·mol^{-1}) was estimated from:

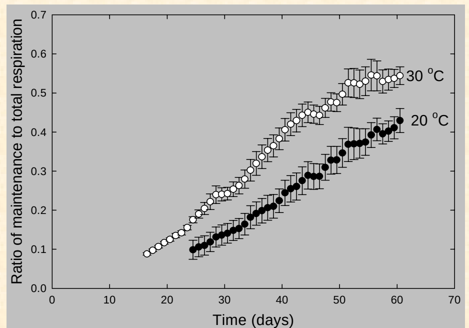
$$\mathbf{CUE = DCG / P_{gross}},$$

where P_{gross} = estimated daily gross photosynthesis.

RESULTS AND DISCUSSION

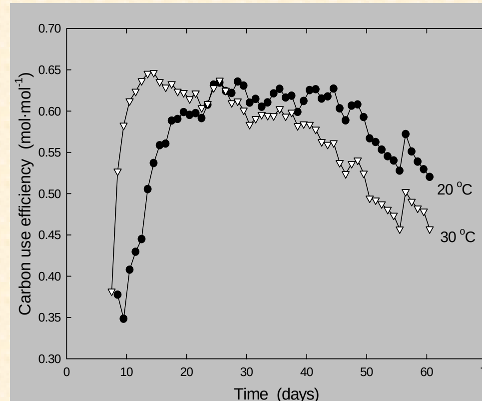


Carbon exchange rate (P_{net} and R_{dark}) of marigolds grown from seed to flowering at 20 or 30 °C. Differences in P_{net} were significant ($P < 0.05$) from day 5 to day 40, while differences in R_{dark} were significant throughout the entire experiment.



Maintenance respiration (mean ± SE) of marigold as a fraction of total respiration. The importance of R_m in the carbon balance of the plants increased throughout plant development and was less at 20 than at 30 °C. Plants at 30 °C had a higher r_m (12.2 mg·g^{-1}·d^{-1}) than those at 20 °C (9.4 mg·g^{-1}·d^{-1}) (Q_{10} =1.3, P =0.001).

r_g was not affected by temperature (0.51 g·g^{-1}).



Carbon use efficiency was lower at 20 than at 30 ° C on day 10 and higher from day 40 until day 51. The low CUE at the start of the growing period was caused by respiration from the germinating seeds. Since **$1/CUE = 1 + r_g + (r_m / RGR)$** (unpublished results), the lower CUE at 30 °C was the result of a combination of the higher r_m and lower RGR at 30 °C.

CONCLUSIONS

1. **Marigolds grown at 30 °C had higher P_{net} and R_{dark} than those at 20 °C during most of the growing period.**
2. **Maintenance respiration accounted for an increasing fraction of total respiration as plants grew.**
3. **Maintenance respiration accounted for a larger fraction of total respiration at 30 than at 20 °C.**
4. **r_m increased with temperature (Q_{10} = 1.3), while r_g was not affected.**
5. **Temperature effects on CUE were caused by effects on both r_m and RGR**
6. **Whole-plant P_{net} is a more important determinant of growth than CUE, r_m, or R_{dark}.**

LITERATURE CITED

van Iersel, M.W. and B. Bugbee. 2000. A multiple chamber, semicontinuous, crop carbon dioxide exchange system: Design, calibration, and data interpretation. J. Amer. Soc. Hort. Sci. 125:86-92.

See abstract #1807 for related research

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