Respiration and Temperature: Is the Q_{10} Concept Meaningful?

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INTRODUCTION

Temperature is well-known to have both short- and long-term effects on respiration, and the Q_{10} is commonly used to describe these effects. Respiration often is divided into growth and maintenance components, with only the maintenance component considered to be temperature sensitive. Therefore, the Q_{10} would be expected to depend on the ratio of growth to maintenance.

Objective: Determine whether temperature effects on the respiration of marigold (*Tagetes patula* L.) can be explained with a growth and maintenance model.

Fig. 1. Marigold seeds were planted in a mixture of sand and perlite and whole-crop gas exchange rates were measured for 60 days.

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 (Fig. 1). Daily *PPF* was 21 mol m^{-2} d^{-1}.

Net photosynthesis, dark respiration, and the carbon content of the plants were used to calculate growth rate, plant dry mass, relative growth rate (RGR), and specific respiration (R_{spec}, dark respiration/dry weight).

Growth (g_r) and maintenance respiration (m_r) coefficients were estimated from the correlation between the R_{spec} and RGR (Fig. 2, right panel):

$R_{spec} = m_r + g_r \times RGR$

Growth (R_g) and maintenance respiration (R_m) were calculated as:

$R_g = g_r \times$ growth rate and **$R_m = m_r \times$ dry mass**

RESULTS AND DISCUSSION

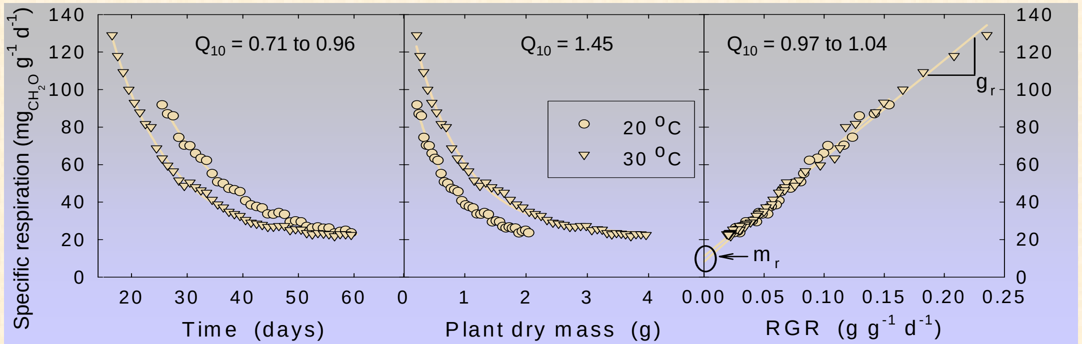

Fig. 2 The Q_{10} for respiration greatly depended on how it was calculated. When plants of the same age were compared (left panel), plants grown at higher temperature had lower specific respiration rates (Q_{10} = 0.71 to 0.96). But when plants with the same dry mass were compared (center panel), the Q_{10} was 1.45, independent of plant size. Plants with the same RGR always had similar specific respiration rates (Q_{10} = 1, right panel).
Growth and maintenance respiration coefficients both were affected by temperature (g_r = 0.56 and 0.52 g g^{-1}, m_r = 8.3 and 11.2 mg g^{-1} d^{-1} at 20 and 30 ºC, respectively; $P < 0.0001$) (right panel).

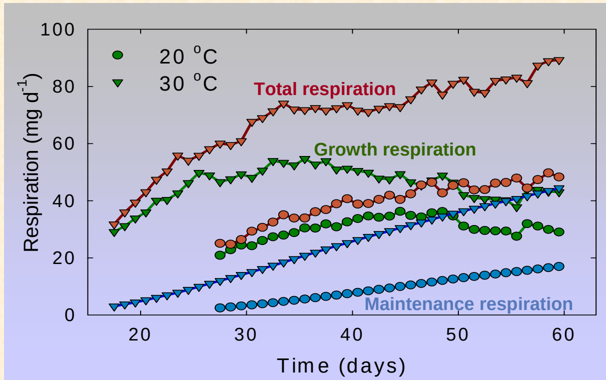

Fig. 3. Growth and maintenance respiration of marigold as affected by temperature. Plants consistently had more maintenance respiration at 30 ºC, because the plants were larger and had a higher m_r than those grown at 20 ºC. Despite the lower g_r at 30 ºC, these plants also had more growth respiration, due to higher growth rates at 30 than at 20 ºC. Total respiration could be accurately described as the sum of growth and maintenance respiration ($R^2 = 0.98$).

CONCLUSIONS

1. Q_{10} estimates varied greatly, and depended on whether plants of the same age, dry mass, or RGR were compared.

2. Respiration rates of the plants could be modeled accurately based on the concept of growth and maintenance respiration.

3. g_r had a Q_{10} of 0.93 and m_r had a Q_{10} of 1.35.

4. Changes in the Q_{10} do not necessarily represent a true physiological acclimation (*i.e.*, a change in g_r or m_r), but can be caused by differences in growth rate or plant size.

5. Using Q_{10} values for respiration provides little or no insight in underlying physiological processes.