The importance of species-specific and temperature-sensitive parameterisation of A / C i models: a case study using cotton (Gossypium hirsutum L.) and the automated 'OptiFitACi' R-package.

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Abstract

Leaf gas exchange measurements provide an important tool for inferring a plant's photosynthetic biochemistry. In most cases, the responses of photosynthetic CO $_2$ assimilation to variable intercellular CO $_2$ concentrations ($A/\ C_i$ response curves) are used to model the maximum rate of carboxylation by ribulose-1,5-bisphosphate carboxylase/oxygenase (Rubisco, V_{cmax}) and the rate of electron transport at a given photosynthetically active radiation (PAR; J_{PAR}). The standard Farquhar-Von Caemmerer-Berry model is typically used with default parameters of Rubisco kinetic values and mesophyll conductance to CO $_2$ (g_m) derived from tobacco that impairs analytical reliability across species. To study this, here we measured the temperature responses of key *in vitro* Rubisco catalytic properties and g_m in cotton (*Gossypium hirsutum* cv. Sicot 71) and derived V_{cmax} and J_{2000} (J at 2000 µmol m $^{-2}$ s $^{-1}$ PAR) from cotton $A/\ C_i$ curves incrementally measured at 15°C to 40°C using cotton and tobacco parameters with our new automated fitting R package 'OptiFitACi'. When applied to cotton, the tobacco parameters produced unrealistic J_{2000}: V_{cmax} ratio of <1 at 25°C, two- to three-fold higher estimates of V_{cmax}, approximately 50% higher estimates of J_{2000} and more variable estimates of V_{cmax} and J_{2000}, compared to model parameterisation with cotton-derived values. We determined that errors arise when using a g_m of 0.23 mol m $^{-2}$ s $^{-1}$ bar $^{-1}$ or below and Rubisco CO $_2$-affinities under ambient O $_2$ ($K_{C}^{21\%O2}$) outside 461 µbar to 627 µbar to model $A/\ C_i$ responses in cotton. We show how the multi- $A/\ C_i$ modelling capabilities of 'OptiFitACi' serves as a robust, user-friendly extension of 'plantecophys' by providing simplified temperature-sensitivity and species-specificity parameterisation capabilities to enable higher accuracy estimates of V_{cmax} and J_{2000}.

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