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Supplementary Material

Appendix 1 – Modified rectangular hyperbolic models for light and CO_2 response curves and the biochemical model for CO_2 response curves.

The modified rectangular hyperbolic model for light response curves can be expressed as follows (Ye 2010):

$$P_N = \alpha \frac{1-\beta I}{1+\gamma I} I - R_D \tag{1}$$

where P_N is the net photosynthetic rate; I is the photosynthetic active radiation; R_D is the dark respiration rate, which can be calculated directly; α is the initial slope of the light response curve of photosynthesis when the light intensity approaches zero; and β and γ are coefficients that are independent of I. The light compensation point (I_c) is the light intensity when P_N=0, and the light-saturated net photosynthetic rate (P_{Nmax}) and light saturation point (I_{sat}) can be calculated using the following formulas:

$$P_{Nmax} = \alpha \left(\frac{\sqrt{\beta+\gamma} - \sqrt{\beta}}{\gamma} \right)^2 - R_D \tag{2}$$

$$I_{sat} = \frac{\sqrt{(\beta+\gamma)/\beta} - 1}{\gamma} \tag{3}$$

The modified rectangular hyperbolic model for CO_2 response curves can be expressed as follows (Ye 2010):

$$P_N = a \frac{1-bC_i}{1+cC_i} C_i - R_p \tag{4}$$

where P_N is the net photosynthetic rate; C_i is the intercellular CO_2 concentration; R_p is the photorespiration rate, which can be calculated directly; a is the initial carboxylation efficiency (CE); and b and c are coefficients that are independent of C_i. The CO_2 compensation point (Γ) is the intercellular CO_2 concentration when P_N=0, and the CO_2-saturated net photosynthetic rate (A_{max}) and saturated intercellular CO_2 concentration (C_{isat}) can be calculated using the following formulas:

$$A_{max} = a \left(\frac{\sqrt{b+c} - \sqrt{b}}{c} \right)^2 - R_p \tag{5}$$

$$C_{isat} = \frac{\sqrt{(b+c)/b} - 1}{c} \tag{6}$$

The biochemical model for CO_2 response curves can be expressed as follows:

$$P_N = min\{w_c, w_j, w_p\}\left(1 - \frac{\Gamma^*}{C_i}\right) - R_D \tag{7}$$

where P_N is the net photosynthetic rate; w_c, w_j, and w_p represent the potential CO_2 assimilation rate supported by Rubisco activity, RuBP and inorganic phosphate regeneration, respectively; Γ^* is the CO_2 compensation point (excluding dark respiration); C_i is the intercellular CO_2 concentration; and R_D is the dark respiration rate under light. The values of w_c, w_j, and w_p can be expressed as follows (Ye 2010):

$$w_c = \frac{V_{cmax} C_i}{C_i + K_c(1 + O/K_o)} \tag{8}$$

$$w_j = \frac{jC_i}{4.5C_i + 10.5\Gamma^*} \tag{9}$$

$$w_p = \frac{3TPU}{1 - \frac{\Gamma^*}{C_i}} \tag{10}$$

where V_{cmax} is the maximum Rubisco carboxylation rate; J is the electron transport rate for RuBP regeneration at light saturation, which is equal to J_{max}; TPU is the triose phosphate utilization efficiency; and K_c and K_o are the Michaelis-Menten constants for carboxylation and oxygenation, respectively (Farquhar et al. 1980).

Cited References

Farquhar GD, von Caemmerer S, Berry JA (1980). A biochemical model of photosynthetic CO_2 assimilation in leaves of C_3 species. Planta 149 (1): 78-90.

Ye Z (2010). A review on modeling of responses of photosynthesis to light and CO_2. Chinese Journal of Plant Ecology 34 (6): 727-740. [in Chinese]