BRC Science Highlight
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Towards a Dynamic Photosynthesis Model to Guide Yield Improvement in C4 Crops

Background/objective

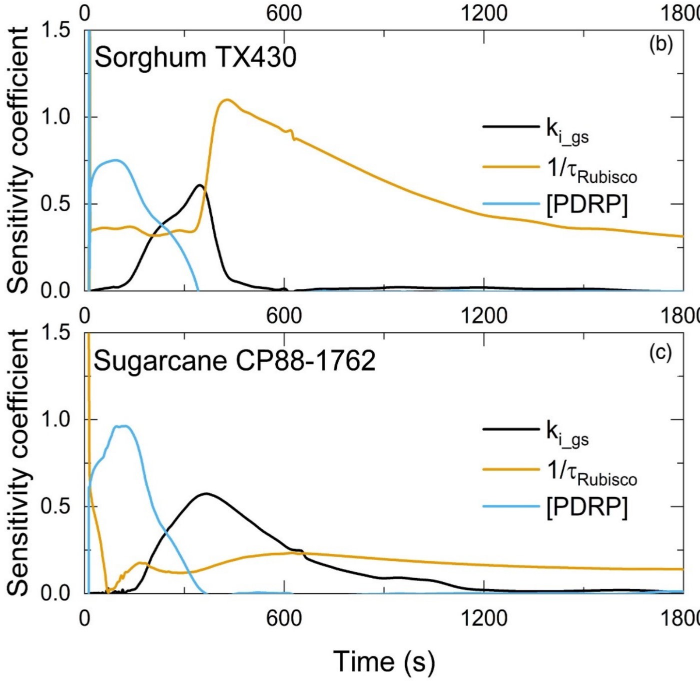
The most productive C4 food and biofuel crops, such as *Saccharum officinarum* (sugarcane), *Sorghum bicolor* (sorghum) and *Zea mays* (maize), all use NADP-ME-type C4 photosynthesis. Despite being productive, their photosynthetic efficiency is only one-third of theoretical. Understanding the basis of these inefficiencies is key for bioengineering and breeding strategies to increase sustainable productivity of these major C4 crops. In this study[1], we measured the rates of CO_2 uptake and stomatal conductance of maize, sorghum and sugarcane under the fluctuating light regimes, that most leaves experience in the field.

Approach

The dynamic model presented here extends a previous C4 metabolic model[2,3] (Wang et al., 2014a,b) to include post-translational regulation, temperature responses of enzymes, dynamic stomatal conductance and leaf energy balance. The model was built by superimposing the dynamic regulation of enzyme activation and stomatal conductance on the previous metabolic NADP-ME C4 leaf photosynthesis model[2].

Results

The average photosynthetic rate through the 30-minute transfer from shade to sun was reduced by 18%, 21%, and 24% in maize, sorghum and sugarcane, respectively, as compared with steady-state photosynthesis. Including post-translational regulation, the temperature response of enzyme activities, dynamic stomatal conductance and a leaf energy balance module, the model closely simulated the measured photosynthetic responses of these crops under fluctuating light, in contrast to the original metabolic model. This suggests that the model captured the key factors affecting the speed of induction upon light fluctuations.



Simulated changes in the sensitivity coefficients of key parameters through photosynthetic induction for sorghum and sugarcane.

Significance

Overall, this study has identified several potential targets for increasing photosynthetic efficiency in these major crops during the frequent light fluctuations that occur in field canopies. CABBI is now beginning to bioengineer these changes into sorghum and sugarcane.

[1] Wang, Y., et.al. 2021. "Towards a Dynamic Photosynthesis Model to Guide Yield Improvement in C4 Crops." ***The Plant Journal*** 107(2): 341-342. DOI: 10.1111/tpj.15365

[2] Wang, Y., et.al. 2014a. "Three Distinct Biochemical Subtypes of C4 Photosynthesis? A Modelling Analysis." ***Journal of Experimental Botany***, 65, 3567–3578.

[3] Wang, Y., et al. 2014b. "Elements Required for an Efficient NADP-Malic Enzyme Type C4 Photosynthesis." ***Plant Physiology***, 164, 2231–2246.

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