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Increased Bundle Sheath Leakiness of CO_2 During Photosynthetic Induction Shows a Lack of Coordination between the C_4 and C_3 Cycles

Background/Objective

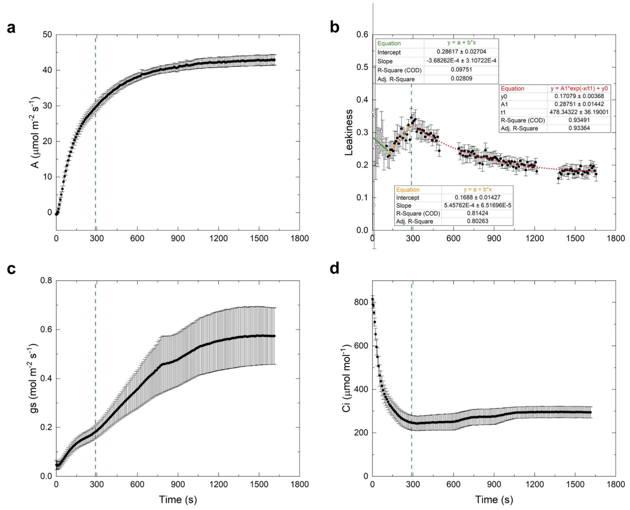
C_4 species (such as maize, sugarcane, and sorghum) are known to be highly productive and have an intrinsic advantage of minimizing energy loss to photorespiration under most conditions. However, C_4 crops still fall well short of theoretical maximum energy conversion efficiency in the field. Understanding this limitation in field conditions is key to increasing the productivity of C_4 crops.

Approach

Previously, CO_2 leakiness (ϕ) was measured at steady-state. We developed a new method, coupling a tunable diode laser absorption spectroscope (TDL) with a gas exchange system, to track ϕ in sorghum and maize through the non-steady-state condition of photosynthetic induction. We hypothesized that ϕ is higher during C_4 photosynthesis activation than at steady-state conditions.

Results

The transient increase in ϕ indicated that capacity to assimilate CO_2 into the C_3 cycle in the bundle-sheath failed to keep pace with the rate of dicarboxylate delivery by the C_4 cycle. Because non-steady-state light conditions occur in the field, the results suggest that ϕ in these major crops is significantly higher and energy conversion efficiency lower than previous measured values under steady-state conditions.



CO_2 assimilation and bundle-sheath leakiness during photosynthetic induction of sorghum measured with an LI-6400XT coupled to a TDL.

Significance/Impacts

The results confirm large efficiency losses due to this lack of co-ordination in the fluctuating light conditions within sorghum canopies. It confirms the conclusion of our modeling that activation of the primary carboxylase, Rubisco, as the key biochemical limitation, and increasingly so under high-temperature stress. The solution we are initiating is up-regulation of Rca (Rubisco activase).

Wang, Y., Stutz, S.S., Boyd, R.A., Bernacchi, C.J., Ort, D.R., Long, S.P. 2022. "Increased Bundle Sheath Leakiness of CO_2 During Photosynthetic Induction Shows a Lack of Coordination between the C_4 and C_3 Cycles." *New Phytologist.* DOI: 10.1111/nph.18485.