CABBI
CENTER FOR ADVANCED BIOENERGY AND BIOPRODUCTS INNOVATION

Environmental Factors have a Greater Influence on Photosynthetic Capacity in C_4 Plants than Biochemical Subtypes or Growth Forms

Background/Objective

Current Earth System Models (ESMs) often rely on C_4 photosynthetic parameters derived from a single species (maize) and assume significant differences between C_4 biochemical subtypes. However, it remains unclear whether photosynthetic capacity (V_{pmaxA} and A_{max}) is primarily driven by these intrinsic traits or by extrinsic environmental conditions. This study aimed to resolve this uncertainty by synthesizing a massive global dataset of C_4 gas-exchange measurements.

Approach

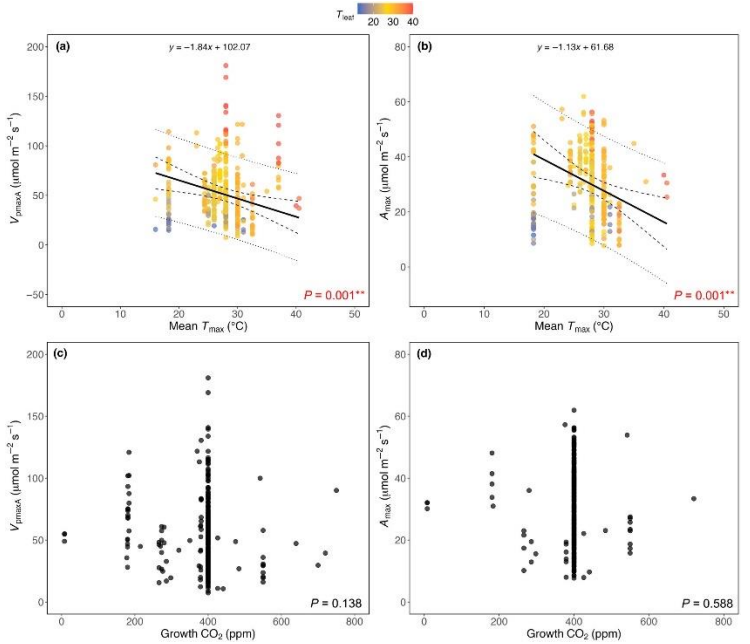
- Researchers collated 1,696 A/C_i (net CO_2 assimilation rate vs. intercellular CO_2 partial pressure) response curves from 74 C_4 species across 12 plant families.
- Multivariate linear mixed-effects models were used to quantify the influence of phylogeny (subtypes, lineages), growth forms, and environmental factors (temperature, light, and CO_2) on photosynthetic parameters.
- V_{pmaxA} (PEP carboxylation activity) and A_{max} (CO_2-saturated photosynthesis) were estimated using a mechanistic C_4 model.

Results

- Environmental factors, particularly growth/measurement temperature and light intensity (PPFD), explained 47–51% of the variation in C_4 photosynthetic capacity.
- Little systematic variation in V_{pmaxA} or A_{max} was found across classical biochemical subtypes (NADP-ME, NAD-ME, PCK) or growth forms.
- Common C_4 model species (e.g., maize, sorghum) showed similar photosynthetic capacity to native species in controlled environments but up to double the capacity when grown in field conditions.

Significance/Impacts

The findings suggest that ESMs can be simplified by focusing on unified environmental response functions for C_4 plants rather than maintaining complex, subtype-specific categories. However, maize-based parameters likely overestimate the capacity of native C_4 species in the field and accounting for that over-estimation would increase the accuracy of global carbon cycle and bioenergy crop projections. This research provides a data-driven foundation for optimizing C_4 crop performance under changing climates.



Environmental conditions, specifically growth temperature and light availability, are the primary drivers of C_4 photosynthetic capacity, accounting for approximately half of the observed variation across diverse species and lineages.

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