BRC Science Highlight
February 2022

Testing Unified Theories for Ozone Response in C_4 Species

Background/objective

Tropospheric ozone (O_3) is a damaging air pollutant that has long been known to negatively impact leaf photosynthetic carbon assimilation, stomatal conductance, growth and development in C_3 plants. While interspecific variability in O_3 sensitivity among C_3 species is well known, variation among C_4 species has been less clearly documented. Leaf traits that determine variation in sensitivity to O_3 across C_4 species has also not been tested. In this study, a side-by-side experimental design was used to test for (a) the effects of elevated O_3 on leaf morphological, structural, chemical and physiological traits, (b) genotypic and species variation in O_3 sensitivity, and (c) relationships between O_3 sensitivity and LMA and between O_3 sensitivity and stomatal conductance in C_4 bioenergy grasses.

Approach

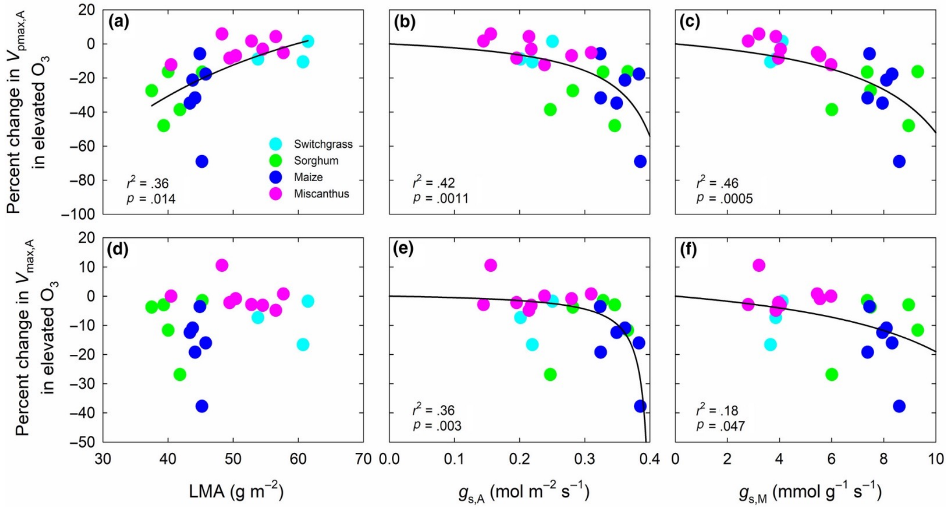
- We investigated leaf morphological, chemical, and photosynthetic responses of 22 genotypes of four C_4 bioenergy species (switchgrass, sorghum, maize, and miscanthus) to elevated O_3 in side-by-side field experiments using free-air O_3 concentration enrichment (FACE).

Results

- Elevated O_3 did not alter leaf morphology, nutrient content, stomatal conductance, chlorophyll fluorescence, and respiration in most genotypes but reduced net CO_2 assimilation in maize and photosynthetic capacity in sorghum and maize.
- The responses of both area- and mass-based leaf photosynthetic rate and capacity to elevated O_3 were not affected by LMA directly but negatively influenced by LMA indirectly through stomatal conductance.

Significance

- These results demonstrate significant variation in O_3 sensitivity among C_4 species, with maize and sorghum showing greater sensitivity of photosynthesis to O_3 than switchgrass and miscanthus.
- To our knowledge, this is the first study to provide a test of unifying theories explaining variation in O_3 sensitivity in C_4 bioenergy grasses. These findings advance the understanding of O_3 tolerance in C_4 grasses and could aid in optimal placement of diverse C_4 bioenergy feedstocks across a polluted landscape.



The percent change of the maximum carboxylation capacity of phosphoenolpyruvate carboxylase (PEPC) per unit area ($V_{pmax,A}$; a-c) and CO_2-saturated photosynthetic rate ($V_{max,A}$; d-f) at elevated O_3 in relation to leaf mass per area (LMA; a, d), and stomatal conductance per area ($g_{s,A}$; b, e) and per mass ($g_{s,M}$; c, f) across 22 genotypes in four species.

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