Should the paradigm of reduced plant drought stress at elevated CO₂ be hung out to dry?

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Rising atmospheric CO₂ concentrations and increasing frequency and severity of droughts will alter the environment for plant growth in the coming century and will challenge agricultural production. Models of future food supply currently extrapolate reduced stomatal conductance at elevated CO₂ into reduced plant water use, conservation of soil moisture, and amelioration of physiological stress under drought. Additional carbohydrate availability under elevated CO₂ is also expected to increase root biomass and access to water under low rainfall conditions. By these two mechanisms, elevated CO₂ is expected to compensate for the deleterious effects of drought on yield. Here, we present a 3-year dataset demonstrating that this prediction does not hold true for field-grown soybean as stress becomes more severe. We grew soybean (Glycine max) under ambient (~390 ppm) or elevated (~585 ppm) atmospheric CO₂ in combination with control or reduced precipitation in the field using Free Air CO₂ Enrichment (FACE) technology at the soyFACE facility in Champaign, IL in 2009-2011. Contrary to expectations, we found that growth at elevated CO₂: (1) did not reduce plant water use and conserve soil moisture during stronger droughts; (2) resulted in greater stomatal closure associated with ABA signals in response to soil drying; and (3) altered nodulation patterns, potentially impairing nitrogen fixation. In combination, these responses led to equal or greater yield loss to drought under elevated CO₂ compared to ambient CO₂. These findings suggest current projections of future crop yield in the Midwest U.S. may be overoptimistic and identify potential targets for crop adaptation to environmental change this century.