How will productivity, evapotranspiration & insect herbivory of the Midwest agroecosystem respond to the combined drought and elevated [CO_2] anticipated for 2050?

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OBJECTIVES

At over 60 million hectares, the soybean (C_3)-maize (C_4) ecosystem is the largest single ecosystem type in the 48 states and dominates the Midwest. We will reduce uncertainty about how projected changes in precipitation and [CO_2] will affect ecosystem C-cycling and water fluxes. Adding retractable rain shelters to an established FACE experiment will allow us to determine these ecosystem responses in a cost-effective manner. The simplicity and uniformity of the soybean-maize system increases our power to detect and quantify treatment effects that can be extrapolated to a wide geographical area.

HYPOTHESES TO BE TESTED

By the mid- to late-21st century, summer precipitation in the Midwest will be up to 40 % lower than today, and [CO_2] will rise to ≥550 ppm. We hypothesize the following:

1) Increased drought stress will depress ET, GPP, NPP across the entire Midwest agroecosystem via reduced stomatal conductance (g_s), photosynthesis (*A*) and leaf sugar and N contents in C_3 (soybean) and C_4 (maize) crops.

2) Elevated [CO_2] will counteract drought effects in C_3 species via direct stimulation of *A*, accompanied by lower g_s, which conserves soil moisture and indirectly stimulates *A*. These will be non-additive interactions.

3) Elevated [CO_2] will counteract drought effects in C_4 species **only** via lower g_s, which conserves soil moisture and thereby indirectly stimulates *A*. This reflects an important difference between climate change effects on the two major components of the Midwest agroecosystem, which needs to be understood.

LOCATION OF RESEARCH

The SOYbean Free-Air Concentration Enrichment (SOYFACE) facility occupies 16 ha adjacent to the University of Illinois campus and is typical of the Midwest soybean-maize ecosystem.

OUTLINE OF METHODS

Rain will be intercepted by a retractable awning at night. Weather records for the site indicate that deploying the awning for half the nocturnal rainfall events will intercept ~30 % of total rainfall. Operation at night avoids shading and adverse effects on daytime CO_2 fumigation. We built and validated a prototype awning in 2006. Lateral movement of soil water into the treatment area was prevented by a 1.2 m deep surrounding barrier. Soil moisture was measured to a depth of 1 m and was decreased by 30%. This drought treatment and measurement methodology will now be deployed in a split-plot design. Over 3 years of soybean-maize rotation there will be control and drought subplots (8 x 4 m) within each of 4 elevated [CO_2] (~550 ppm) and 4 control (~380 ppm) plots. This will assess 3 of the 4 NICCR ecological endpoints of interest under drought and [CO_2] treatments: NPP, EET and susceptibility to insect pests. NPP will be assessed using established allometric relationships, litter traps and destructive harvests. EET will be continually monitored by the residual energy balance method and soil water profile by capacitance probe. Insect damage will be assessed by insect collections and imaging of leaf area loss. The mechanism of response will be determined by measurements and modeling of leaf physiology and chemistry.

EXPECTED DELIVERABLES

(1) estimates of how the ecological function of the dominant land use in the Midwest U.S. will respond to the increased summer drought and elevated [CO_2] predicted for 2050; (2) characterization of the distinct responses of maize and soybean that results from their different photosynthetic pathways; and (3) elucidation of the physiological basis of response, which is necessary to inform future modeling studies and management strategies.