**Introduction**

**Background**
Rising temperatures impact our food supply. A study done by Siebers et al. (2015) shows that when soybeans, the world’s fourth most popular commodity crop, are exposed to heatwaves, their yield is decreased by ~10%. Many plant traits could be negatively affected by heat stress including photosynthesis, plant development, and flower and pod production. Our research aims to better understand which physiological processes in soybean are negatively affected by heat stress in order to identify targets for future soybean production.

**Our Experiment**
Using infrared heat arrays, two different cultivars of Illinois soybeans will be continually heated. At the end of the growing season all of the soybean plants will be harvested and their biomass will be collected. Throughout the experiment data will be collected on photosynthesis, leaf area index and, overall productivity of the plants. These measurements will show direct effects of heat on photosynthesis, plant growth, reproductive development, and yield. Our physiological results from plants growing in the field will be used to calibrate a crop model (CLM-APSIM model) to further demonstrate how heat stress will impact soybean productivity across the Midwest U.S.

**Procedure**

**The Setup**
Our experiment consists of four elevated temperature controlled rings (+1.5°C, +3.0°C, +4.5°C, and +6.0°C) as well as ambient temperature plots in open air field conditions. All elevated rings have infrared canopy sensors that constantly check the temperature. The plots are irrigated and heat stressed plants are given additional water as needed to minimize drought stress. The heating arrays are constantly kept at 1.2-1.3 m above the top of the soybean canopy.

**Data Collection & Methods**

**Development Data:**
- Vegetative and reproductive stages of the soybeans were scored three times per week according to the developmental stages described by Fehr et al. (1971) and illustrated in the figure above.

**Photosynthesis and Leaf Respiration:**
- Photosynthetic capacity was measured on two plants of each cultivar from each plot (24 plants) using an infrared gas analyzer (LI-6800, LIcor).
- A mature trifoliate leaf was cut from the plant and taken to the lab for measurements.
- Photosynthesis (A) was measured at a range of intercellular [CO2] concentrations (c) in order to investigate how temperature impacted maximum photosynthetic capacity (A).

**Leaf Area Index:**
- Using a LAI 2000, with a 45° lens cap, measurements of leaf area index (i.e., m² of leaf per m² of ground) were taken immediately after dawn in diffused sunlight.
- Once per week in both ambient and elevated temperature plots, we took 2 replicate measurements of 1 above canopy reference measurement and 4 below canopy measurements forming a diagonal transect between two rows.
- The lens cap was aligned parallel to the rows and perpendicular for the other.

**Biomass Harvest:**
- This will be done several times, before maturity and after maturity.
- Before maturity the whole soybean plant is cut off at the stem ½ cm above the ground and separated into leaf mass, flower mass, pod mass, and, stem/shoot mass.
- Those samples are dried and weighed separately.
- After maturity the plant is hand harvested. Seeds and shoots are mechanically separated to determine harvest index (HI).

**Results**

**Plant Height Differences**
Plant height was marginally taller in the maturity group 4 genotypes compared to maturity group 3. Different temperature treatments did not significantly affect plant height.

**Leaf Area Differences**
Increasing temperature treatments decreased total leaf area per plant in both maturity group 3 and maturity group 4 genotypes.

**A/C, Curves**
Measurement of photosynthetic rate (A) at different intercellular [CO2] will be used to study two processes that limit A in the leaf (Farquhar et al. 1980). The initial slope of the plot is used to estimate Rubisco, limited photosynthesis, and the slope after the asymptote is where A is no longer limited by Rubisco, but by the capacity for the electron transport chain to regenerate sugars and generate ATP and NADPH.

**Terminology (Denoted by Subscript)**
1. CLM-APSIM is a mathematical model which aims to understand how natural and human changes in vegetation affect climate across the globe.
2. Growth Stages of Soybeans are separated into emergence, cotyledon, vegetative and, reproductive stages. Emergence is simply the first shoot pushing through the soil after planting. Cotyledon is after the shoot is fully emerged and there are two seed “leaves” (these “leaves” are the cotyledons). In V1 there is one trifoliate whose leaf margin no longer touches the numbering trend continues indefinitely. In V1 there are flowers on the bottom nodes of the plant. Etc.
3. LI-6800 is a commonly used piece of equipment that measures CO2 and H2O exchange along with chlorophyll fluorescence in order to measure the photosynthesis process. More information at www.licor.com.
4. A.v. C, Curves are plots of photosynthesis (A) measured at different intercellular (CI) (c) which allow estimation of the biochemical limitations of photosynthesis (either Rubisco limitation or electron transport limitation).
5. The LAI 2000 is an instrument that measures vegetative canopy structure by using radiation interception from gaps in the canopy. It uses a fisheye lens and different angled lens caps to measure how much radiation is intercepted by the soybean canopy above it.
6. Harvest Index (HI) is the ratio between the seed mass of the crop vs. the mass of all of the above-ground biomass.
7. Rubisco (Ribulose-1,5-bisphosphate carboxylase/oxygenase) is the initial carbon fixation enzyme in the Calvin cycle.
8. ATP (adenosine triphosphate) and NADPH (Nicotinamide adenine dinucleotide phosphate) are energy and reducing chemicals that are produced in the light reactions of photosynthesis and used in the Calvin cycle.

**References**

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