HIGH THROUGHPUT PHENOTYPIC EVALUATION OF DROUGHT-RELATED TRAITS IN SOYBEAN

HUA BAI* AND LARRY C. PURCELL

DEPARTMENT OF CROP, SOIL AND ENVIRONMENTAL SCIENCES, UNIVERSITY OF ARKANSAS, FAYETTEVILLE

INTRODUCTION

Drought stress limits crop growth and yield in soybean, but there are relatively few tools available to assess the ability of different genotypes to tolerate drought. Aerial infrared image analysis, carbon isotope discrimination ($\Delta^{13}C$) and oxygen isotope composition ($\delta^{18}O$) were evaluated as potential tools for identifying drought tolerance in soybean. $\Delta^{13}C$ shows promise as a selection criterion for identifying genotypes with improved water use efficiency (WUE). Drought stress leads to stomatal closure, reducing transpiration and increasing canopy temperature and resulting in decreased $\delta^{18}O$ (Madhava et al., 2010). Aerial infrared imaging offers a rapid method to identify genotypes with cooler canopy and drought tolerance.

HYPOTHESES

- Slow-wilting genotypes will have a greater WUE due to the conservation of soil moisture when soil water is plentiful resulting in a decrease in both $\Delta^{13}C$ and $\delta^{18}O$.
- Canopy temperature will be lower in slow-wilting genotypes under drought stress because of continued transpiration.

OBJECTIVE

- To detect the differences in $\Delta^{13}C$, $\delta^{18}O$, and canopy temperature among genotypes that are already known for their wilting phenotypes.

MATERIALS AND METHODS

- **Genotypes:** 10 genotypes from cross between 'Benning' and PI 416937 including 5 fast and 5 slow wilting (Abdel-Haleem et al., 2012)
- **Water Treatment:** Fully-watered (FL), partially-watered (PT), and rainfed (RF) from line source irrigation system
- **Design**: Strip split plot with 4 replications
- **Seed Sample:** Geno-grind for $\Delta^{13}C$ and $\delta^{18}O$
- **Infrared Image Analysis**: Relative canopy temperature values from 1 (cool) to 256 (hot)
- **Aerial Platform:** tethered balloon or kite

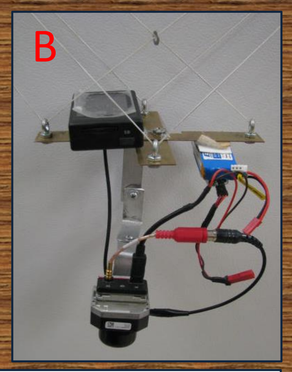

Figure 1. (A) Balloon or kite platform for aerial image and (B) picavet for the thermal infrared camera. Infrared camera with picavet was lifted 50 to 75 m above experiments using either a large tethered balloon or a kite.

RESULTS

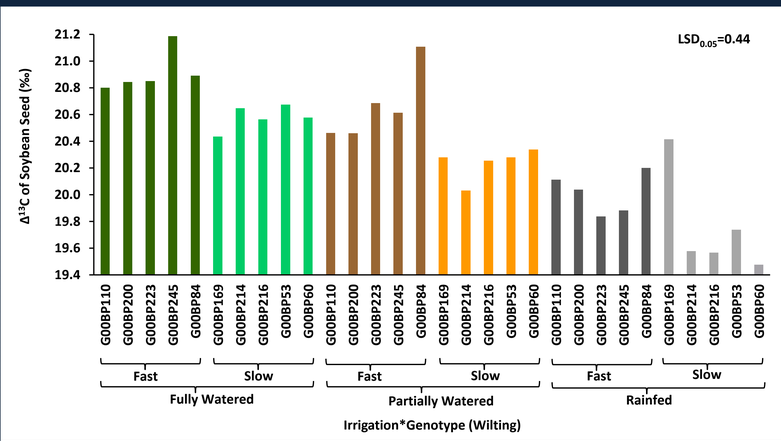

Figure 2. $\Delta^{13}C$ values of soybean seed for each genotype under each water treatment in 2012.

- Irrigation*genotype(wilting), irrigation treatment, and wilting type had significant effects on $\Delta^{13}C$ in 2012.
- Reduced water availability decreased the $\Delta^{13}C$ values (i.e., increased WUE).
- Slow-wilting genotypes generally had lower $\Delta^{13}C$ values (i.e., higher WUE) than fast-wilting genotypes.
- In 2013, the $\Delta^{13}C$ of seed significantly decreased with increasing drought stress; in 2014, slow-wilting genotypes had low $\Delta^{13}C$ values (i.e., high WUE) compared to fast-wilting genotypes.

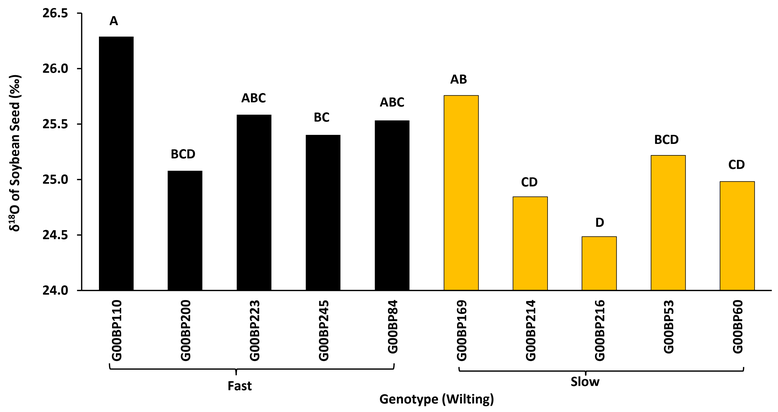

Figure 3. $\delta^{18}O$ values of soybean seed for each genotype across irrigation treatments in 2013.

- Wilting type and genotype(wilting) had significant effects on $\delta^{18}O$ in 2013.
- There is a trend that slow-wilting genotypes generally had lower $\delta^{18}O$ values than fast-wilting genotypes.
- In contrast to previous report by Madhava et al. (2010), $\delta^{18}O$ values increased with decreased water availability in 2012.
- In 2014, a very wet year, none of the effects showed significant difference.

RESULTS

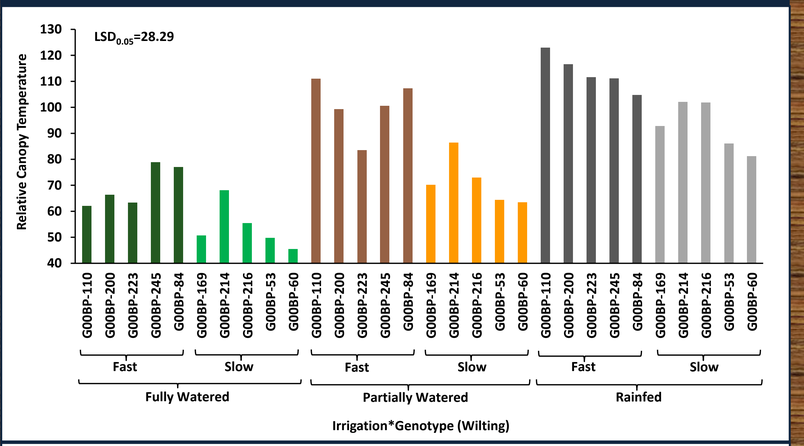

Figure 4. Relative canopy temperature for each genotype under different water treatments in Sep 6, 2013 .

- Irrigation*genotype(wilting), irrigation*wilting, irrigation and wilting type had significant effects on relative temperature in Sep 6, 2013.
- Reduced water availability generally increased relative temperature .
- Slow-wilting genotypes generally had lower relative temperature than fast-wilting genotypes under each water treatment.
- In 2014, increased drought stress increased relative temperature on 3 of the imaging days; slow-wilting genotypes had lower relative temperature than fast-wilting genotypes on 2 of the imaging days.

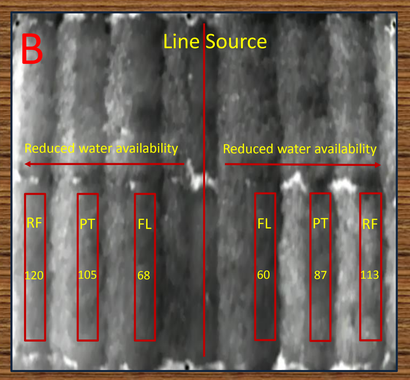

Figure 5. (A) Line source irrigation system and (B) infrared image with relative canopy temperature for different plots.

CONCLUSIONS

- $\Delta^{13}C$ generally decreased with increasing drought stress; $\delta^{18}O$ and canopy temperature generally increased with increasing drought stress.
- Slow-wilting genotypes had lower $\Delta^{13}C$, $\delta^{18}O$, and canopy temperature.

REFERENCES

- Abdel-Haleem H., Carter T.E.J., Purcell L.C., King C.A., Ries L.L., Chen P., Schapaugh W.J., Sinclair T.R., Boerma H.R., 2012. Mapping of quantitative trait loci for canopy-wilting trait in soybean (Glycine max L. Merr). *Theoretical and Applied Genetics* 125:837-846.
- Madhava, H.B., M.S. Sheshshayee, R. Devendra, T.G. Prasad, and M. Udayakumar. 2010. Oxygen (^{18}O) isotopic enrichment in the leaves as a potential surrogate for transpiration and stomatal conductance.

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CONTACT INFORMATION

Dr. Larry Purcell: lpurcell@uark.edu

Hua Bai: bhua@uark.edu