# Drought Tolerance in Cultivated and Wild Soybean Species

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## Introduction

Drought can severely decrease soybean (*Glycine max*) yields, but alleviating drought stress through irrigation is costly. Reserves of fresh water in the U.S. continue to decline with population growth and, perhaps, climate change. Genetic improvement of soybean varieties for drought tolerance is likely the most sustainable strategy for achieving acceptable yields during drought. Agronomic drought tolerance requires that a plant maximizes $CO_2$ intake with minimal water loss via the stomata. Indicators of drought tolerance include water use efficiency (WUE) and early stomata closure with soil drying. "Soja" (*Glycine soja*) is the wild relative of soybean. This non-cultivated species is adapted to the desert climate of Northern China. If either WUE or early stomata closure were present in soja genotypes, then it may be possible to transfer these desirable traits for drought conditions into current soybean varieties.

**The objectives of this research were to**

1) Compare WUE between soja and soybean.
2) Test soja for early stomata closure as compared to soybean under drought stress.

## Methods

- Growth chamber temperatures were 26 and 30 °C.
- After 2 weeks, pots (9 L) were adjusted to maximal plant available water conditions.
- Water was withheld from drought plants during a dry down period. Controls were watered daily.
- Water use was measured daily by weighing (Fig.1). The difference in weight between measurements was assumed to be water loss via transpiration.
- Shoot mass was regressed against water use for plants harvested sequentially during the dry down (Fig.2).
- Transpiration of drought plants was expressed relative to the average of the controls (Fig.4).

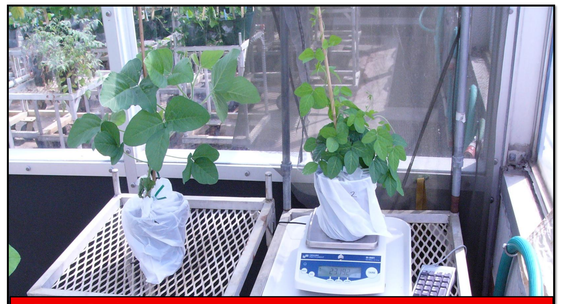

Fig. 1. Soybean and soja plants were weighed daily to measure transpirational water loss as drought progressed. Pots were wrapped in plastic to prevent evaporation.

## Results

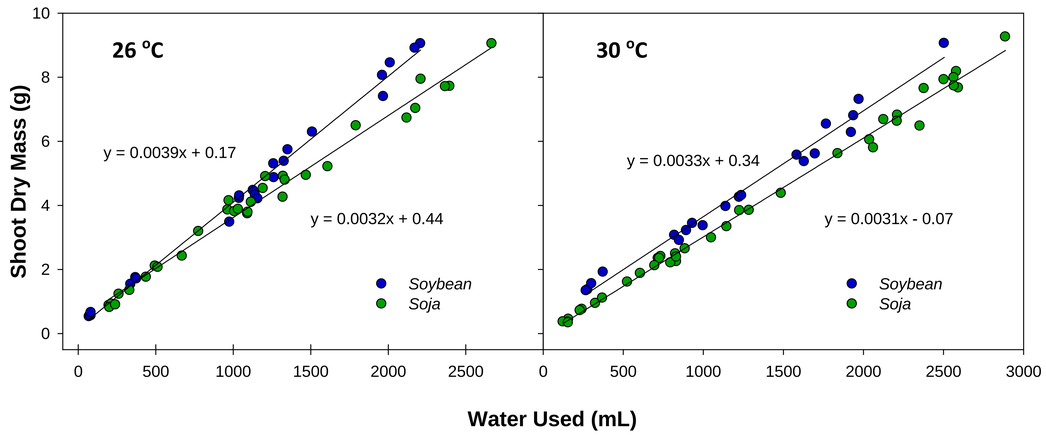


Fig. 2. Dry mass accumulation per milliliter of water transpired by soybean and soja at 26 and 30 °C. Data points represent sequential harvests of well-watered plants. The greater the slope of the regression equation, the higher the water use efficiency in shoot dry matter production.

- Using a given amount of water, soja produced the same or less biomass than soybean.
- Water use efficiency was similar for soja and soybean regardless of temperature when plants were provided with adequate water.

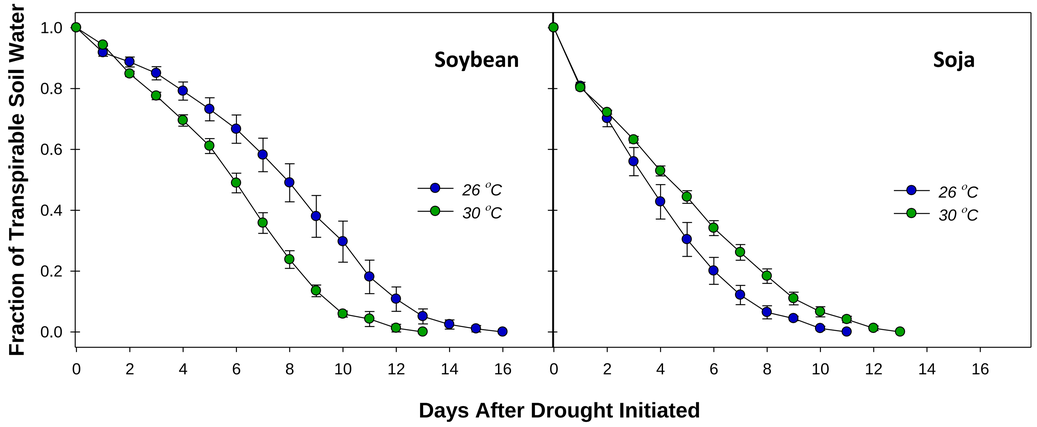


Fig. 3. Soil dry down by soybean and soja as a function of time in experiments conducted at 26 and 30 °C. Fraction of transpirable soil water describes soil water status near field capacity (value = 1) and permanent wilting (value = 0).

- There was a significant interaction of temperature and species on the duration of a dry down.
- Dry down periods lasted from 11 to 16 days at 26 °C and for 13 days at 30 °C.
- Soybean dry down was more rapid at 30 °C than at 26 °C. In contrast, soja dried down slower at 30 °C.

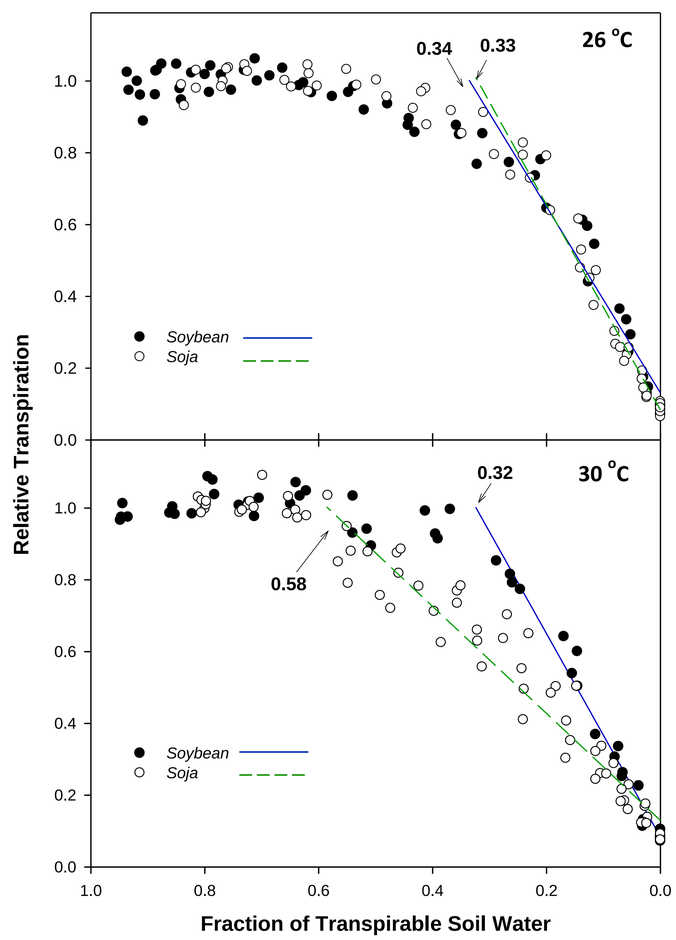


Fig. 4. Relative transpiration response of soybean and soja to soil drying at 26 and 30 °C. FTSW values included in figure to indicate transpiration breakpoints. Higher FTSW values indicate earlier stomatal closure.

- Transpiration declined at a similar soil water content for soybean and soja at 26 °C.
- At 30 °C, soja reduced transpiration at a significantly higher FTSW than soybean.

## Conclusions

1) Soja does not have higher water use efficiency than soybean. However, it exhibits early stomata closure at high temperatures.
2) Temperature dependent stomatal closure may confer drought tolerance by reducing transpiration and conserving soil water as drought conditions worsen and soil water depletes.