Seed Growth Dynamics of Soybean (*Glycine max*) Experiencing Drought Stress

Patrick J. Curl* and Tyson E. Ochsner

Department of Plant and Soil Sciences, Oklahoma State University contact:patrick.curl@okstate.edu

Introduction

Soybean production is often limited by heat and drought stress during reproductive stages.

Drought stress can manifest for short periods between rainfall or irrigation events.

Stress at R5 (beginning pod fill) can result in the abortion of the soybean or a reduction in the final bean size. (Palmer et al., 1996)

Objectives

Quantify the loss or recovery of bean growth resulting from a short-term drought at peak susceptibility (R5).

Determine matric potential at which plant stress manifests as a reduction in bean growth.

Materials and Methods

Controlled environment via growth chamber. Day time temperature of 27.8° C, night time of 20° C. Carbon dioxide ranged between 500-700 ppm. Humidity 20-40%. Day length mimicked conditions of May – October. Alternating placement of metal halide, high pressure sodium, and 440 nm (blue) LED as light sources.

Soybeans (Asgrow 45X6, indeterminate) were inoculated and planted in 1.5 liter pots. At V5, select plants were transplanted into 10 liter pots (loam soil) with Decagon soil moisture sensors (5TE) inserted into root ball.

Plants remained well watered from VC – R5. At early R5, short-term water stress was induced via a four day dry down where no water was added. (4 plants experienced dry down, 1 plant remained well-watered)

Nondestructive measurement of bean diameter (via digital calipers) began one day prior to dry down and lasted for a period of 25 consecutive days for all initiated beans at R5.

Volumetric water content was logged in 20 minute intervals from V5 to termination. (Utilized Rosetta within Hydrus to estimate soil hydraulic properties.)

References

Palmer, J., E.J. Dunphy, and P. Reese. 1996. Managing drought-stressed soybeans in the Southeast. Clemson Extension. DRO-24.

Allen, R.G., L.S. Periera, D. Raes, and M. Smith. 2006. Crop Evapotranspiration. FAO Irrigation and Drainage. p. 161-166.

Figure 1. *Left*. Digital calipers measuring the bean diameter within the pod. *Right.* Labeling of nodes and pods necessary to maintain records for 448 individual beans.

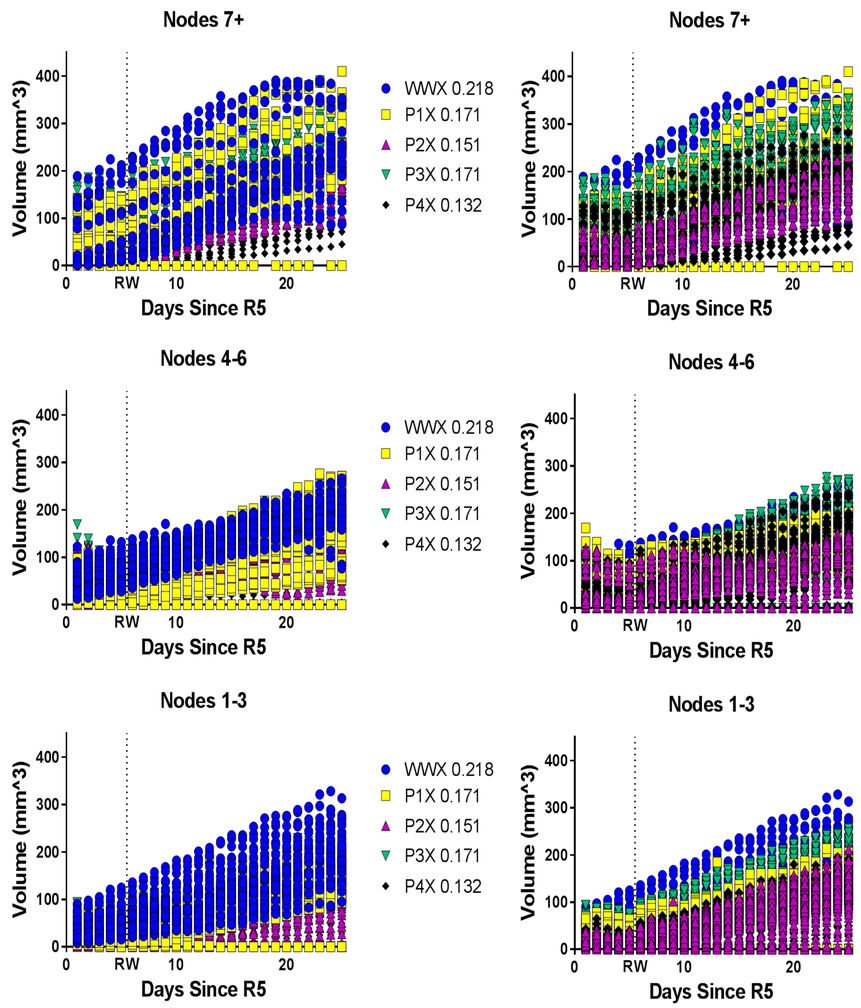

Figure 2. *Left Column.* Volume of individual soybeans for all plants with the well-watered treatment (blue) overlaid on stressed plants. Points falling below the blue points indicate cumulative growth reduction due to water stress, points on x-axis indicate accumulation of aborted beans. *Right Column.* Reverse side of graph displaying ability of soybeans to recover from growth lost during initial stress (*legend identification denotes the lowest water content experienced before re-watering*).

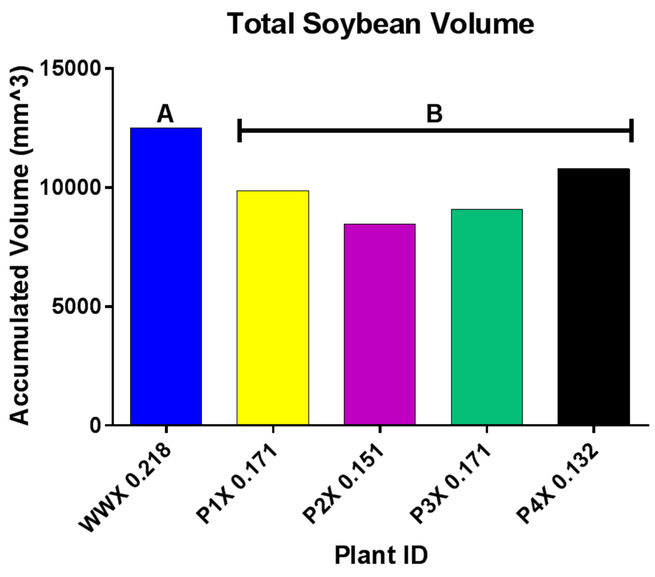

Figure 3. Accumulated volume for all soybeans on a plant from the initiation of stress (Early R5) to the end of data collection (Late R6). A four day drought resulted in a lasting reduction of soybean volume.

Results

During drought stress, all the soybeans experienced negative growth rates while the well-watered control experienced an average growth rate of 7.02 mm^3 $bean^{-1}$ day^{-1} during the same period.

No abortions occurred in the well-watered treatment while a total of 33 beans (8.9% of total) were aborted across drought stressed plants.

Soybean recovery was dependent upon location within the plant. Middle and upper nodes were able to approach or reach the volume of corresponding soybeans by the end of R6 (Full Seed). Soybeans on basal nodes never fully recovered to reach the volume obtained by the well-watered treatment.

Volume was reduced by the drought stress as the well-watered treatment accumulated greater volume than the drought stressed treatments, over the period from R5-R6.

Accumulation of bean volume is highly dependent on the level of stress being experienced by the plant. Moisture contents >0.19 cm^3 cm^{-3} (or approximately -530 kPa) resulted in optimal bean growth. Plants experiencing matric potentials below -530 kPa began suffering stress resulting in a reduction of bean growth. Further stress can result in the loss of bean volume and the subsequent loss of crop yield.

Discussion

Differences in levels of stressed bean recovery between nodes is likely a result of assimilate allocation. Many of the source leaves connected to the plant were within the region of nodes 4-6 where late season recovery occurred. Beans located on nodes lowest in the plant (nodes 1-3) were further from the attachment point of the source leaves and were least able to recover upon improved conditions.

Bean growth declines as soybeans experience matric potentials more negative than -530 kPa. This value likely increases or decreases with changing atmospheric demand. (Allen et al., 2016)

Short-term drought at R5 can reduce final yield, even when late season conditions are ideal.

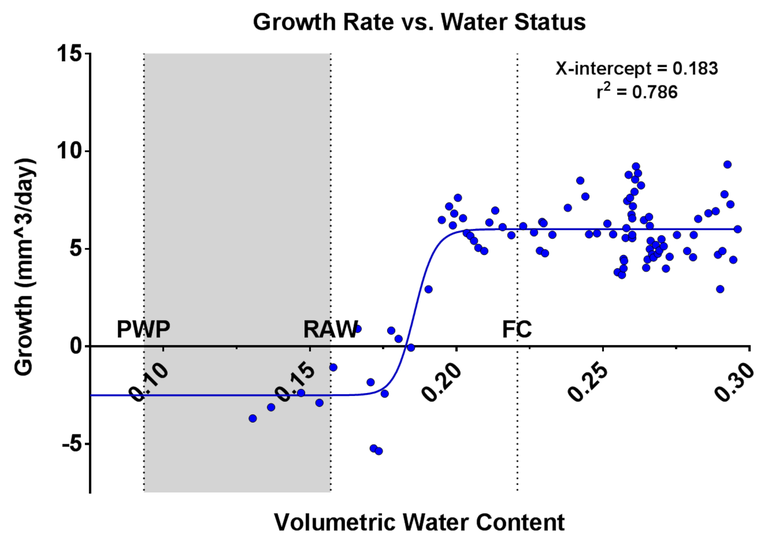

Figure 4. Average growth rate exhibited for soybeans experiencing varying water conditions. X-intercept indicates point where greater stress results in the loss of bean volume. (RAW = 0.5 plant available water, PWP = permanent wilting point -1500 kPa, FC = field capacity -33 kPa)

This work was supported by the Oklahoma Agricultural Experiment Station and the Oklahoma State University College of Agricultural Sciences and Natural Resources. The authors are grateful for the contributions of Dr. Sergio Abit and Dr. Gopal Kakani to this work.