Using 1-m Rooting Columns to Better Simulate Field Soil Water Profile and Soybean [*Glycine max* (L.) Merr.] Growth Response Under Controlled Environment Conditions

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Introduction

- Soybean is the number one field crop grown in Ontario with a cultivated area of more than 1 million ha & a value of over $1.2 billion [1].
- It is grown mostly under rainfed conditions, so soil water deficits significantly limit Ontario's soybean yield in most growing seasons with demonstrated losses in field experiments ranging from 8-24% [2,3].
- Such yield-limiting water deficits usually occur with no obvious outward signs of stress such as leaf wilting, but result in fewer pods per plant, reduced seed size, and hastened crop maturity, which shortens the grain filling stage [3].
- The pattern of soil water availability in frequently watered small pots used in most plant-water relationship studies is different from a field environment [4].
- The rooting environment in small pots is not a realistic simulation of the field rooting environment since the volumetric soil water content (VSWC) profile differs strongly with depth in the field, but not in small pots.
- Thus, deep rooting columns in controlled environment conditions may provide more realistic soil water profile variation with depth and be more representative of field conditions.

Objectives

- Developing a controlled environment culture system that permits realistic rooting depths and establishment of soil water profile gradients that mimic field conditions.
- Selecting the best growth medium based on rooting depth, soil water distribution, and biomass accumulation.

Methodology

- The soybean cultivar *OAC Bayfield* was grown in a field soil (FS) from Elora Research Station amended with different volumes of granitic sand and peat-based potting mix in polyvinyl chloride (PVC) tubes having an inside diameter of 10 cm and length of 100 cm.
- The experiment was arranged as a randomized complete block, with 6 treatments, 6 replicates and 4 border tubes, in the Crop Science Building's greenhouse at the University of Guelph in the 2015 summer season.
- The 3 soil mixtures tested were: 0% FS (a mixture of 2/3 granitic sand, 1/3 potting mix by volume), 50% FS, and 67% FS mixes. In the latter two cases, the balance was 2/3 sand, 1/3 potting mix.
- Tubes were either watered to 75 or 100% water holding capacity.
- A commercial 20-20-20 plus micro nutrients fertilizer was applied at the rate of 0.8 g per tube dissolved in 100 mL solution and thoroughly mixed with the soil mixture before it was loaded in the tube.
- The tubes were filled to approximately 1 cm below the top of the tube in a systematic fashion of loading and packing.
- Measurements included**:** VSWC, calculated from time-domain reflectometry (TDR) measurements; whole-plant water use; shoot, root, & whole-plant biomass production.

Results and Discussion

Figure 1: Culture system developed for studying rooting traits in soybean using 1-m rooting tubes. Tubes are drilled on the sides to allow for TDR measurements of VSWC. Plastic liners allow for removal of intact root systems, so that root distribution can be accurately determined by depth.

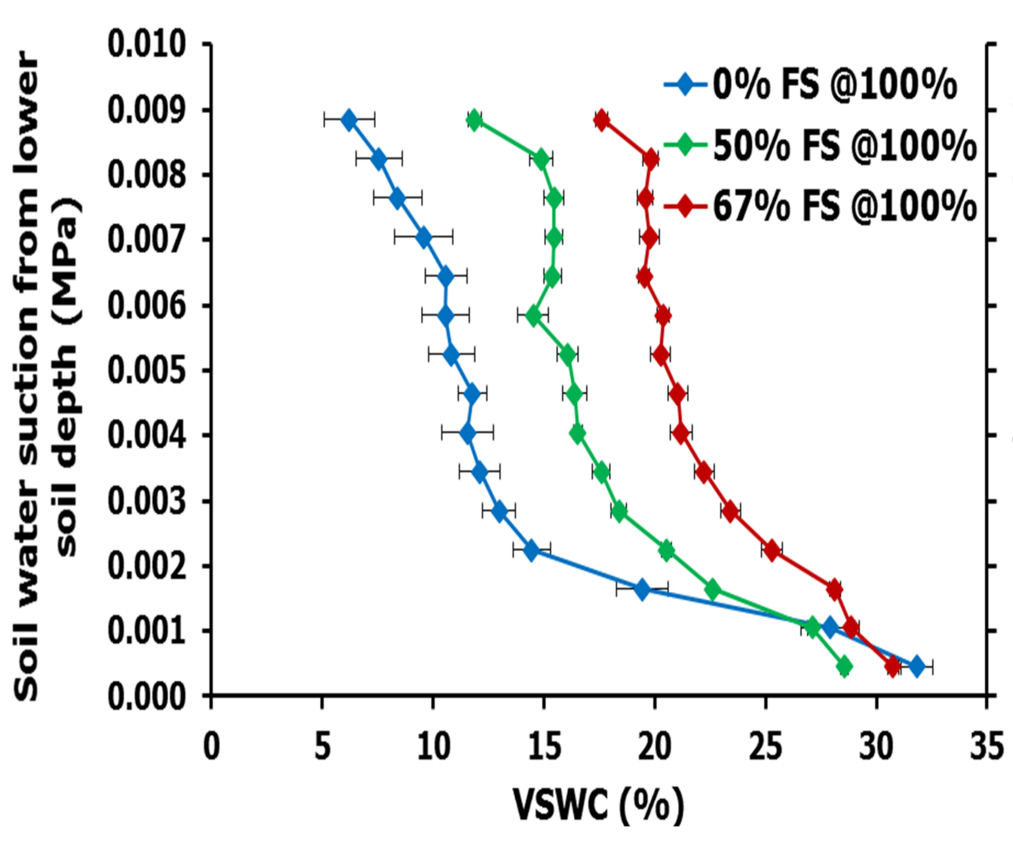

Figure 2: Soil water release curves of the 3 soil types watered to 100% tube capacity. Soils are 0% FS (blue symbols), 50% FS (green symbols), or 67% FS (red symbols). Data are means of 6 tubes in each case, measured on date of planting.

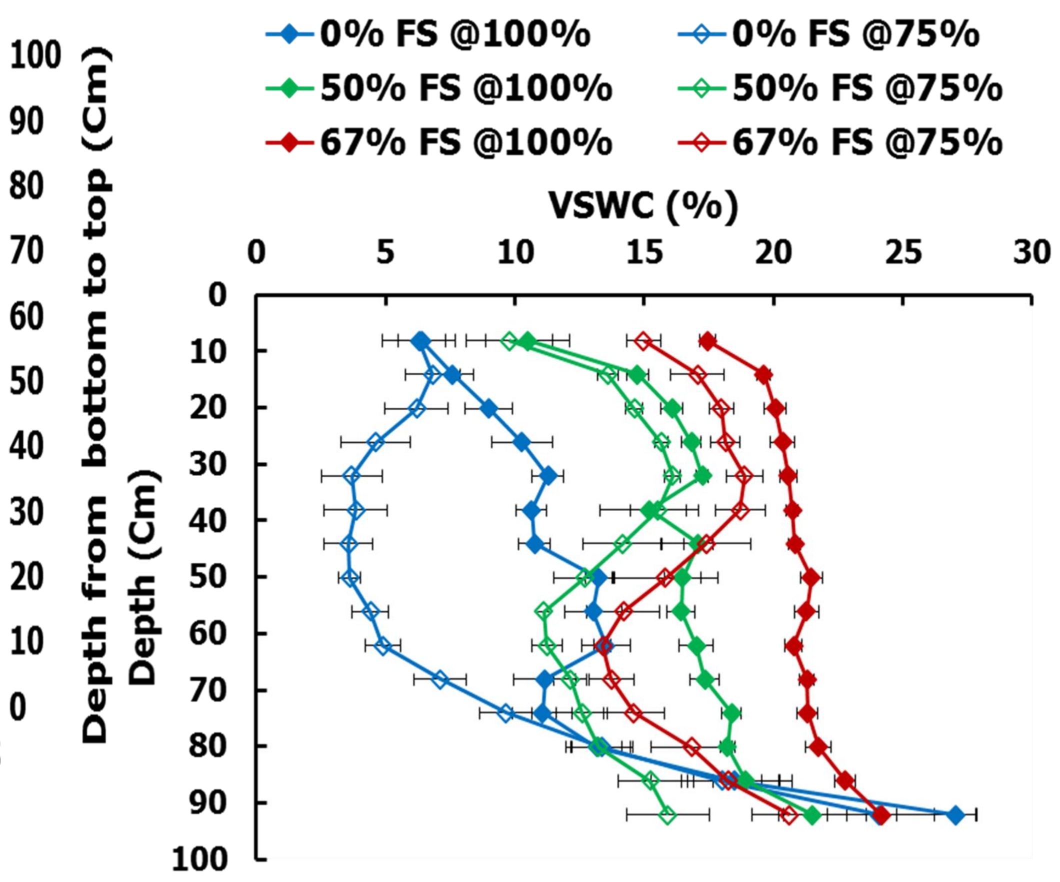

Figure 3: VSWC profile by depth of the 3 soil types tested, measured 33 days after planting. Soils are 0% FS, 50% FS, or 67% FS, watered either to 75% tube capacity (open symbols) or 100% tube capacity (closed symbols). Data are means of 6 tubes in each case.

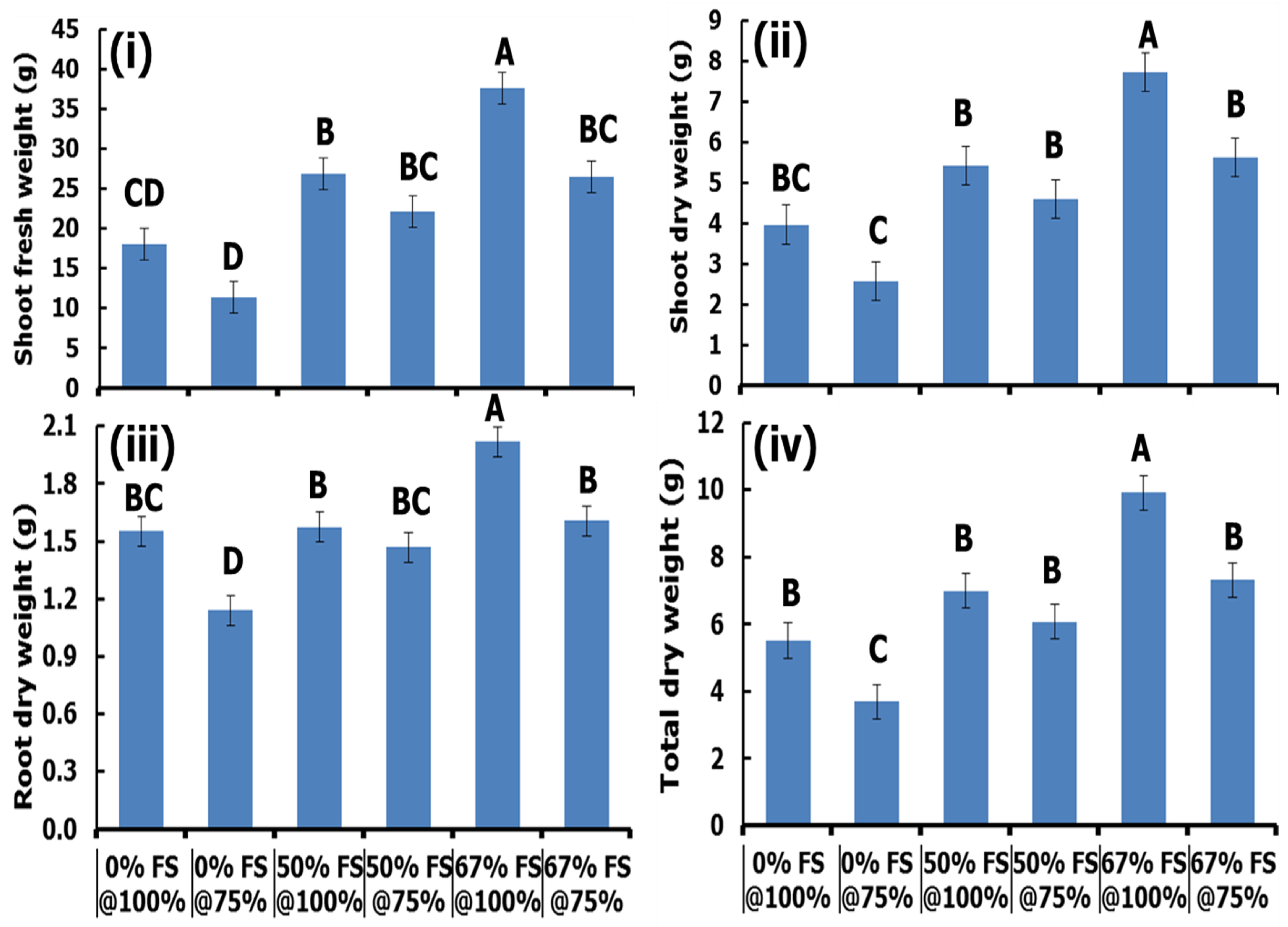

Figure 4: Effect of soil type and watering strategy on final shoot fresh weight (i), shoot dry weight (ii), root dry weight (iii), and whole-plant dry weight (iv). Data are from the same experiment as shown in **Figure 3**.

- The soil mixture with 67% FS mix watered to 100% of the tube water holding capacity resulted in a uniform field-like soil water profile with depth (**Figures 2 & 3**), the smallest change in VSWC between 0 and 0.01 MPa matric potential (**Figure 2**), and the highest biomass accumulation (**Figure 4**).
- Watering to 75% of the tube water holding capacity of the 67% FS mix significantly reduced shoot, root, and whole-plant dry matter accumulation by 27, 20, and 26%, respectively (**Figure 4**).
- These results suggest the 67% FS mix as the best growth medium for subsequent studies with root functional traits affecting drought tolerance in soybean under controlled environment conditions.

Conclusions & Implications

- A 1-m rooting column provides a reasonable field-like soil water profile by depth.
- Increasing the fraction of field soil increased soil water holding capacity, and increased uniformity of VSWC with depth.
- Plant biomass accumulation was highest in the mixture that contained the highest fraction of field soil.
- This study provides novel phenotyping tools to select root traits that could decrease soybean yield losses under soil water deficit conditions.

Acknowledgement

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References

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