Root and shoot responses of grafted soybean to water deficit stress

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Introduction

- Soybean (*Glycine max* L.) is an important crop with a wide range of agricultural and industrial uses.
- Water availability often limits soybean yield.
- Root growth is critical to maintain water uptake under water limited conditions
- Grafting techniques facilitate examination of the roles of rootstock and scion for root and shoot growth.
- Limited information on the response of root systems to grafting is available for soybean.
- Deep-rooting genotypes and a better understanding of mechanisms and tradeoffs associated with deep rooting are needed to develop varieties that can access more water and withstand drought conditions.

Objective

- To characterize root systems of two soybean genotypes under well-watered conditions and in response to dry-down.
- To determine the influence of self- and reciprocal grafting on root system characteristics.

Materials & Methods

- Two genotypes previously identified to differ in rooting depth (PI424405B, deep roots (A); PI567531 shallower roots (B)).
- Seeds were sown in deep tubes (1.52 m height; 15 cm diameter) filled with a 4:1 (v/v) mixture of Mexico silt loam : dry sand. At the time of sowing, tubes were at field capacity and were placed in the field and were covered by a moving rainout shelter during precipitation events (Figure 2).
- Nine days after sowing, self- and reciprocal grafts were made as follows: Scion/Rootstock: A/A, A/B, B/B, B/A

  Both genotypes (A and B) were also grown without grafting. However, to standardize development, seeds for these treatments were sown 5 days after those that were destined for grafting.
- The wedge grafting method was used and a 2.5 cm long silicone tube was placed over the wedge (Fig. 1).
- Grafted plants were placed in a custom-made healing chamber to maintain high humidity and limit light intensity for 5-6 days.
- Water was added to the well-watered treatments based on the weight of each tube. Tubes were weighed every 2 to 3 days and water was added based on the tube weight to maintain well water conditions. No water was added to the dry-down treatments at any time over the course of the experiment.
- 43 days after sowing of the grafted treatments, the experiment was terminated. Stems were cut and shoot tissue processed to evaluate leaf area and shoot biomass.
- Roots were removed from the tubes and partitioned into six depth-increments. Each section was washed to remove soil from roots. Roots were scanned and analyzed using (WinRhizo, Regent Instruments INC., Canada).
- All treatments were replicated six times and analysis of variance was conducted using PROC GLM (SAS 9.4). Significant differences between treatments were determined using Fisher's (LSD) test at $\alpha \leq 0.05$.

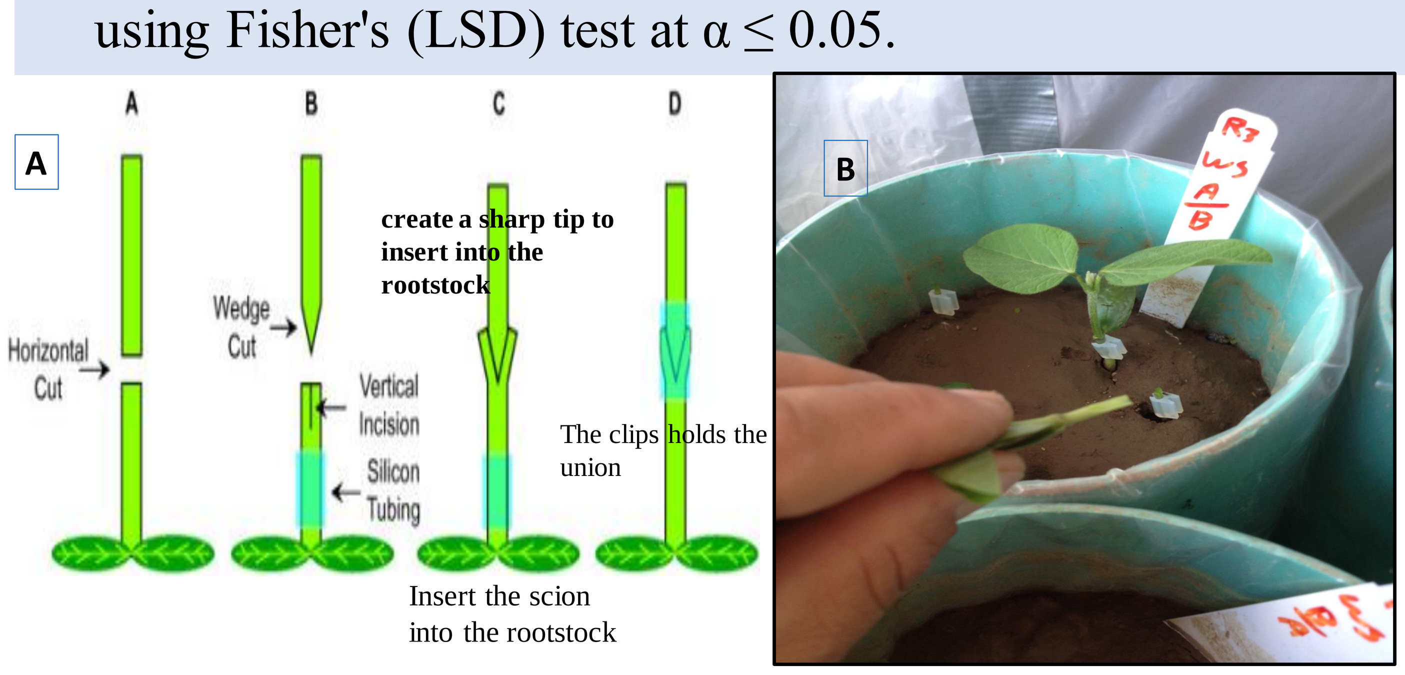

Figure 1: Illustration of the wedge grafting technique used for this study (A). Grafting was conducted on plants that were directly sown into the deep tubes (B).
(Nisar *et al*. Plant Methods 2012, 8:50)

Figure 2: One set of cylinders arranged according to RCBD design and placed under rainout shelter. Deep tubes arranged in a channel under field conditions shortly after removal of the custom-made healing chamber.

Results

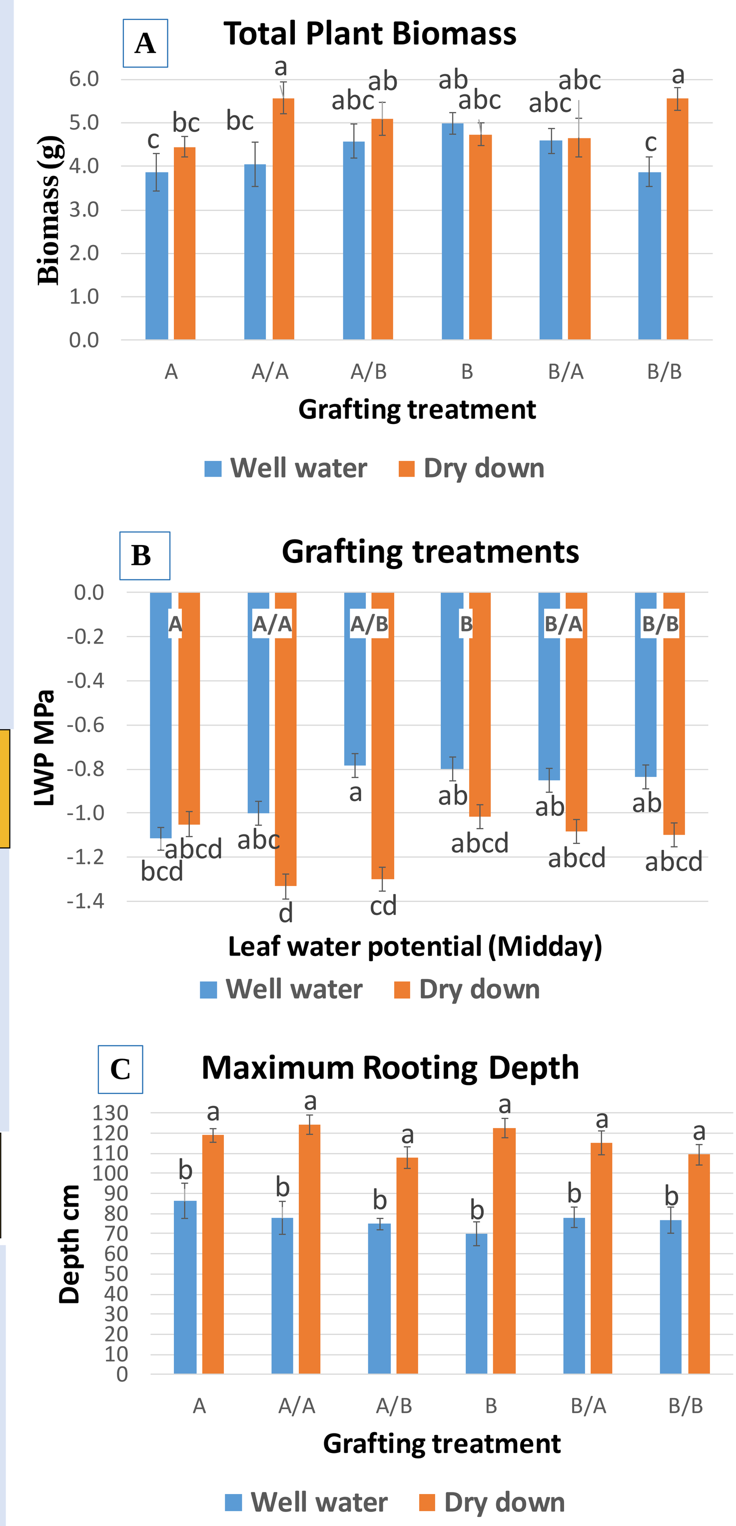

Figure 3: Total plant dry weight in both well-watered and dry-down treatments (A). Mid-day leaf water potential measured 2 days prior to harvest (B). Maximum rooting depth in both well-watered and dry-down treatments (C). Letters indicate significant differences at P<0.05.

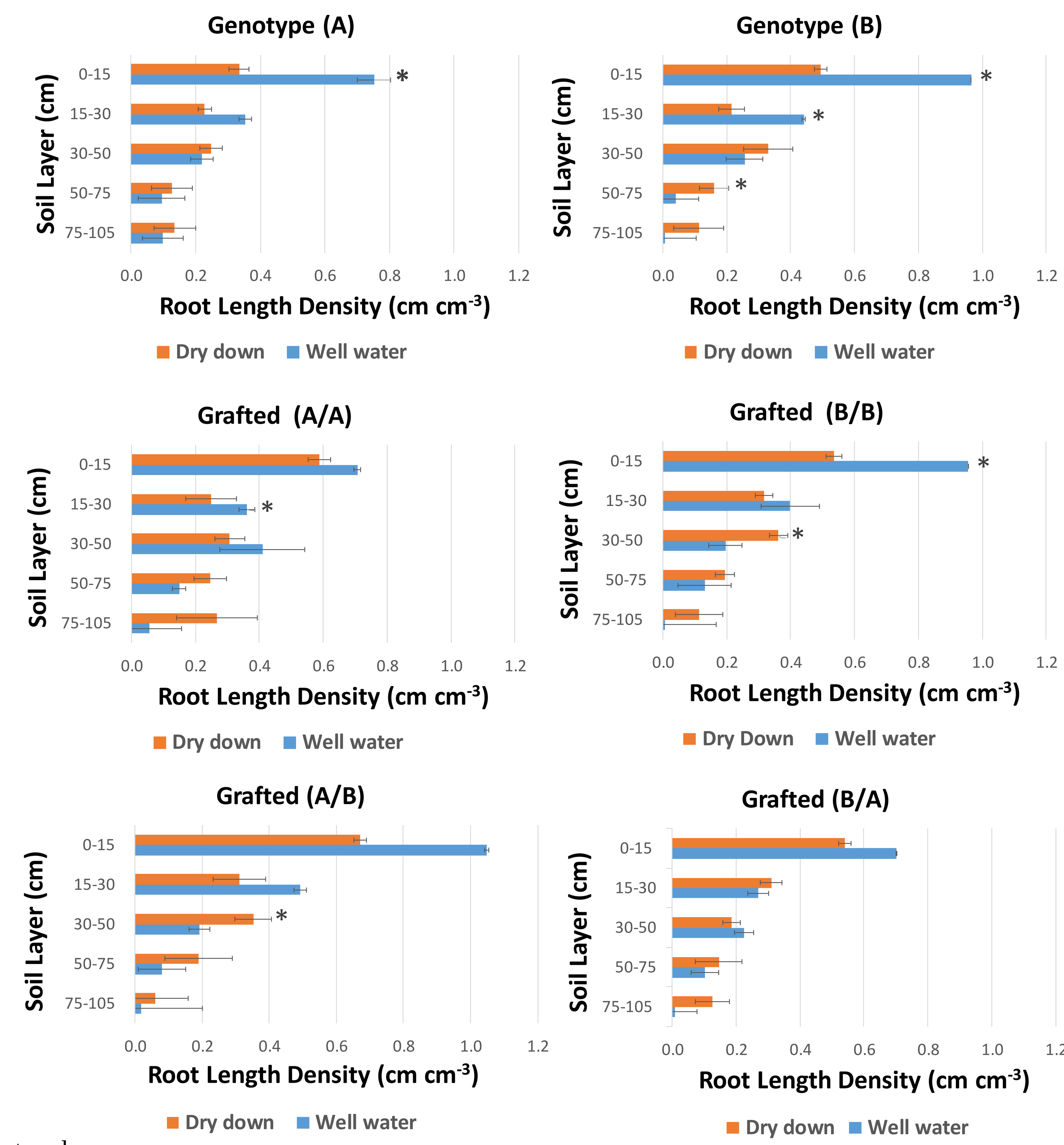

Figure 4: Variation in root length density with soil depth from two soybean genotypes subjected to different grafting treatments in well-watered and dry down treatments. * Indicates significant difference between water treatments within each soil layer at P<0.05.

Results:

- Water treatment did not influence total biomass of reciprocal grafting and un-grafted plants (Fig. 3A).
- Self-grafted plants accumulated more total biomass in the dry-down treatment than in the well-watered treatment (Fig. 3A).
- Two days before termination of the experiment, mid-day leaf water potentials of plants in the dry-down treatment were not different from those of well-watered plants, except for the A/A and A/B grafted plants (Fig. 3B).
- Rooting depth increased in response to the dry-down treatment. Average maximum rooting depth across all treatments was 1.5 fold that of the well-watered treatment (Fig. 3C).
- In general, root length densities in the top 30 cm were greater for well-watered plants than plants in the dry-down treatment (Fig 4).
- Root length densities at depths below 50 cm tended to be greater in the dry-down treatment than in the well-watered treatment (Fig.4. Genotype (B), grafted (B/B) and grafted (A/B).).
- Root length density differences between the two genotypes were observed in well-watered and dry-down treatments. Root length densities at the depth of 75 cm were greater for genotype B than genotype A in dry down treatment.

Conclusions

- The dry-down treatment induced reallocation of root length from shallow strata to deeper region.
- Root elongation in the dry-down treatment was sufficient for continued water acquisition without inducing severe water deficit stress throughout most of the experiment.
- Whether self-grafted or grafted onto genotype B, the scion of genotype A had a stimulatory effect on root growth in most soil strata, particularly under dry-down conditions.
- Additional research is needed to confirm and expand upon these results.

References

- Vadez V., Rao, S., Kholova, J., Krishnamurthy, L., Kashiwagi, J., Ratnakumar, P., Sharma, KK., Bhatnagar-Mathur, P., and Basu, P. S. (2008). Root research for drought tolerance in legumes: quo vadis? *Journal of Food Legumes*, (21), 77-85.
- Nisar, N., Verma, S., Pogson, B. J., & Cazzonelli, C. I. (2012). Inflorescence stem grafting made easy in Arabidopsis. *Plant methods*, *8*(1), 1.