**SCSB Final Report**

**General Information**

**Principal Investigator(s) Name:** Sruthi Narayanan  
**Organization:** Clemson University

**Date:** 1/25/2021

**Quarter:** 4

**Proposal Information**

**Title:** Water use efficient soybeans for South Carolina

**Amount Expended to Date:** $7,500 (100%)

**Progress Assessment**

Twelve soybean genotypes (maturity groups, V-VIII) were planted on 06/02/2020 at Piedmont Research and Education Center, Pendleton, SC and on 06/15/2020 at PDREC, Florence, SC. Plants were maintained under rainfed conditions. The soil at Pendleton was clayey and contained a hardpan (penetration resistance > 1.5 MPa). The soil at Florence was sandy. We measured root system architecture and morphology in-situ using a CI-602 Root Imager at biweekly intervals. We measured volumetric water content (m3 m–3) at 0.30-m depth intervals by the neutron attenuation method up to 1-m depth. These data were used to estimate crop water use. We also measured physiological parameters related with water use efficiency such as leaf area index. At harvest maturity (growth stage R8), plants were harvested for measuring seed yield. The elite SC breeding line SC07-1518RR exhibited a useful root-related mechanism that contributes to better performance and water use efficiency. It did not partition more assimilates to roots at the expense of aboveground biomass and yield in order to improve root function (i.e., absorption of water and nutrients). Instead, it restricted root distribution at lower depths and preferentially distributed more roots at deeper depths to improve root function. This improved root trait and this genotype will be useful for breeding programs in variety development. Detailed Project Results are given under ‘Additional Information’.

**Key Performance Indicators (KPI’s)**

All KPI’s have been met.

1.This study identified soybean genotypes with increased biomass, seed yield, and water use efficiency (SC07-1518RR, N09-12854, N09-13890, and Crockett)

2. The study has also identified a useful root-related mechanism that contributes to better performance and water use efficiency in SC, which will be useful for soybean breeding programs in variety development

4. Project results were disseminated to soybean producers through reports and personal communications. Publications are under preparation.

**Next Steps**

Publications based on the project results are under preparation. A manuscript will be submitted to a reputed journal soon. The student who worked on this project is writing his thesis based on the results. He will defend and graduate this year.

**Additional Information**

Twelve soybean genotypes belonging to maturity groups V-VIII were tested in this study. The name of the genotypes, maturity groups, and other characteristics are given in Table 1. The elite SC breeding line SC07-1518RR had the highest biomass at both locations (Figure 1). The exotic pedigree line N09-12854, slow wilting line N09-13890, and forage variety Crockett also had relatively high biomass at both locations. SC07-1518RR also had the highest seed yield at Florence (sandy soil), whereas it was intermediate in seed yield at Pendleton (clayey soil) (Figure 1). N09-12854 was one among the highest seed yielders at both locations. N09-13890 was one among the best seed yielders at Florence, but the lowest seed yielder at Pendleton. The genotypes that produced high biomass and/or seed yield: SC07-1518RR, N09-12854, N09-13890, and Crockett used just equal or even less amounts of water than other genotypes (Figure 2). This demonstrated that the good performance of these genotypes in terms of biomass and/or seed yield was not the result of increased water use. The above genotypes (SC07-1518RR, N09-12854, N09-13890, and Crockett) also ranked among the highest for water use efficiency at Pendleton (Figure 3). Genotypes did not differ for water use efficiency at Florence (Figure 3). When we measured the root development, we observed that these genotypes (SC07-1518RR, N09-12854, N09-13890, and Crockett) were not having a more profuse or dense root system (in terms of total root count and root length; Figure 4). This suggests that these genotypes did not invest assimilates to produce more roots and increase total root length to enhance water absorption. On the other hand, the same genotypes were ranked among the highest for leaf area production (Figure 5). Genotypes SC07-1518RR and N09-12854 had the highest LAI at Pendleton and Florence, respectively. The trends in root and leaf production of these genotypes suggest that they might have preferentially partitioned assimilates to leaves rather than roots in order to maximize dry matter production (photosynthesis), which could later increase seed yield. Though the genotypes that produced high biomass and seed yield did not appear to invest assimilates to produce a larger root system, some of them preferentially distributed more roots at specific depth (Figure 6). Example is SC07-1518RR, for which the total root count and root length were less or similar to that of other genotypes at lower depths (0-50 cm), but they were higher at deeper depths (52-70 cm). This may be a beneficial root trait for improving yield and water use efficiency in our soils. In this case, plant does not need to partition more assimilates to roots at the expense of aboveground biomass and yield in order to improve root function (i.e., absorption of water and nutrients). Instead, it restricts root distribution at lower depths and preferentially distributes more roots at deeper depths to improve root function. The same genotype also appeared to delay root senescence along with Crockett (another high biomass and seed yielder) and N05-7432 (slow wilting) (Figure 7).

Considering that the total precipitation at both location was adequate for a soybean crop and was sufficient to prevent any sort of drought stress (Figure 8), the above results are applicable to a wet year (no-drought) or well-watered conditions.

**Table 1.** Characteristics of the soybean genotypes used in the study.

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| --- | --- | --- |
| Genotype | Maturity group | Characteristics/Comments |
| R01-581F | V | Sustained nitrogen fixation under drought |
| Boggs | VI | Intermediate in wilting |
| N06-7023 | VI | Slow wilting |
| NC-Roy | VI | Fast wilting |
| N09-12854 | VII | Exotic pedigree |
| N09-13890 | VII | Slow wilting (Pedigree traces back to a slow wilting line, PI 471938) |
| NC-Raleigh | VII | Conventional cultivar -Check |
| NTCPR94-5157 | VII | Slow wilting |
| SC-14-1127 | VII | Exotic pedigree |
| Crockett | VIII | Forage |
| SC07-1518RR | VIII | Elite South Carolina breeding line – Check |
| N05-7432 | VIII | Slow wilting |



Figure 1. Biomass production at physiological maturity and seed yield at harvest maturity of soybean genotypes at Pendleton and Florence. DAP - Days After Planting.

 

Figure 2. Total water used by soybean genotypes at Pendleton and Florence. DAP - Days After Planting.



Figure 3. Water use efficiency (ratio between biomass and water use for a specific interval) of soybean genotypes at Pendleton and Florence.



Figure 4. Total root numbers (root count) and length (total root length- sum of lengths of all roots) of soybean genotypes at three different measurement dates at Pendleton. Genotypes were generally at V8, R4, and R5-R6 growth stages at 44, 77, and 105 days after planting (DAP).



Figure 5. Leaf area index (LAI) of soybean genotypes at Pendleton and Florence



Figure 6. Root production at various depths. Depths 1,2,3, and 4 refer to ~ 0-18, 18-35, 35-52, and 52-70 cm, respectively.



Figure 7. Changes in total root count and root length over time at Pendleton. A decrease in these traits indicate senescence.



Figure 8. Total precipitation during the soybean growth season at Pendleton and Florence. DAP- Days After Planting