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Research Project

Studies of Root System Architecture in Soybean using Computer Vision

Abstract

Root system architecture (RSA) studies are tedious, susceptible to introduced variation, measurements are time consuming and the extracted features may not translate to meaningful outcome, i.e., increase in yield or other important traits. With the advent of computer vision, there is a renewed interest in uncovering the hidden half, i.e., discovering trait correlations within and between genotypes and phenotypes. This study included 300 diverse soybean accessions from a wide geographical distribution and deployed 2-D (in controlled conditions) and stereo imaging platforms (field tests), processing and data analytic tools to deep phenotype for important RSA traits using in-house imaging software, ARIA. Both 2-D and stereo imaging platforms reveal tremendous genetic variability for RSA traits for root shape, length, mass, and angle. The stereo imaging platform developed for this study makes it possible to phenotype hundreds of genotypes and extract numerous RSA traits. In addition, the 2-D platform developed is non-destructive, adding observations of seedling root growth and development.

Research Focus

- Explore global soybean germplasm for diverse RSA traits.
- Create innovative methods for lab and field based screening utilizing current technology including computer vision, command line based automation, cloud databases, machine learning and stereo vision.
- Utilize lab and field experiments to identify genetic drivers for RSA traits and impose prediction models on the USDA core collection.

Data Collection

Lab-based: Phenotypic data collection without removing the root from the medium allowing for time series growth and development measurements

- 300 plants are grown simultaneously in one growth chamber. Each plot, consisting of two plants of one genotype is removed, placed on the stage where individual images were captured. Root images were captured using a Canon T5i camera and a laptop running DigiCamControl software. Our pipeline worked automatically, to rotate, crop and rename images using optical character recognition (OCR) of each barcode label. ARIA performs digital image analysis of 30 root traits including total root length, tap root length, number of secondary roots, rhizosphere surface area as well as allows for calculation of growth rate of each trait.

Field-based: Collect of phenotypic spatial RSA traits via point cloud using a stereo imaging platform to correlate with lab-based method.

- 300 genotypes were planted in hill plots using two reps of a RCBD. Seedling (V1) and at maturity (R8) stages were targeted. At the seedling stage, plants were extracted in a 25.4cm diameter to a 30cm depth using two individuals with trenching spades. Roots are cleaned, then suspended and rotated. Two digital cameras remote controlled, one below the root and one to the side. The ARIA software has been expanded to utilize multiple images to build point clouds via this stereo imaging platform developed to allow comprehensive spatial evaluation of RSA of field grown plants.