Marie De Gracia Coquerel[1], Nurzaman Ahmed[1], Madison Payne[1,2], and Nadia Shakoor[1]

[1]Donald Danforth Plant Science Center
[2]Virginia Polytechnic Institute and State University

October 30, 2023

Abstract

Roots are vital for crop development, facilitating water and nutrient uptake, adapting to soil conditions, and supporting above-ground plant growth. Sorghum, a climate-resilient and versatile cereal crop, plays a significant role in global food security and bioenergy production, making its study especially relevant. Analyzing root architecture (RA) traditionally involves destructive and time-consuming methods that preclude longitudinal observations of individual plants. Here we used minirhizotrons (MR), wireless, non-destructive devices developed to capture root imagery. With MR, we aim to identify sorghum varieties that are conducive to prolonged underground carbon storage through larger and deeper roots. Insights into sorghum's RA could also better elucidate the link between RA and above-ground productivity.

We conducted two experiments using the MR cameras. The 2023 summer field experiment at the Danforth Field Research Site (FRS) assessed the impact of tilling and cover crop practices on RA in two sorghum varieties, employing 96 MR tubes across 48 plots. An indoor trial on 35 sorghum lines used 73 MR tubes, with RootSnap software facilitating image analysis. Preliminary findings indicate that MR predicts root biomass with high accuracy, both overall and at each depth, and can determine root color with 90% accuracy. Finally, through the development of a neural network, we aim to utilize image analysis to predict root biomass at various depths, providing a labor-saving alternative to soil coring. We also address challenges, including the limited dataset size and image noise, through enhanced feature engineering and provide a comprehensive comparison of multiple machine-learning techniques.

Sorghum Roots in Focus: Leveraging Minirhizotrons and Machine Learning for Root Growth Analysis and Prediction

***Marie de Gracia Coquerel*[1]**, *Nurzaman Ahmed*[1], *Madison Payne*[1,2], *Nadia Shakoor*[1]

[1]*Donald Danforth Plant Science Center, Shakoor Lab*
975 N. Warson Rd, St. Louis, MO.63132, USA
[2]*Virginia Polytechnic Institute and State University,*
Blacksburg, VA.24061, USA

ORCiD: 0000-0001-7426-8892

Keywords: Sorghum bicolor, root architecture, root analysis, Minirhizotrons, Neural Network

Roots are vital for crop development, facilitating water and nutrient uptake, adapting to soil conditions, and supporting above-ground plant growth. Sorghum, a climate-resilient and versatile cereal crop, plays a significant role in global food security and bioenergy production, making its study especially relevant. Analyzing root architecture (RA) traditionally involves destructive and time-consuming methods that preclude longitudinal observations of individual plants. Here we used minirhizotrons (MR), wireless, non-destructive devices developed to capture root imagery. With MR, we aim to identify sorghum varieties that are conducive to prolonged underground carbon storage through larger and deeper roots. Insights into sorghum's RA could also better elucidate the link between RA and above-ground productivity.

We conducted two experiments using the MR cameras. The 2023 summer field experiment at the Danforth Field Research Site (FRS) assessed the impact of tilling and cover crop practices on RA in two sorghum varieties, employing 96 MR tubes across 48 plots. An indoor trial on 35 sorghum lines used 73 MR tubes, with RootSnap software facilitating image analysis. Preliminary findings indicate that MR predicts root biomass with high accuracy, both overall and at each depth, and can determine root color with 90% accuracy. Finally, through the development of a neural network, we aim to utilize image analysis to predict root biomass at various depths, providing a labor-saving alternative to soil coring. We also address challenges, including the limited dataset size and image noise, through enhanced feature engineering and provide a comprehensive comparison of multiple machine-learning techniques.