THEME 1

GPR based root and SOC imaging

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INTRODUCTION

Selection of the ideal crops for our industrial and food needs should consider not only the value of the harvested above ground products, but also the local and global environmental services it provides in terms of terrestrial carbon (C) phyto-sequestration and improved soil organic matter enrichment. Selection of ideal crops is well under way. What is lacking, however, is high throughput phenotyping (HTP) and integrated real-time data analysis technologies for selecting ideal genotypes within these crops that also confer recalcitrant high biomass or perennial root systems not only for Carbon phyto - sequestration, but also for adaptation to conservation agro-ecosystems, increasing soil organic matter and soil water holding capacity. We propose to achieve a significant advancement in the use of ground penetrating radar (GPR) to phenotype root biomass and 3D architecture, and to quantify soil carbon sequestration. GPR functions by transmitting a broadband frequency electromagnetic energy signal into the ground. By measuring signal attenuation and signal return time, GPR is able to detect different dielectric properties of unique belowground materials, i.e., roots vs. soil. Signal returns can be quantified on GPS coordinates from a planned grid of field plots or landscapes and rendered into a 3-D field, allowing for visualization and mapping of belowground root biomass. In this context, GPR can be used for genotypic selection in breeding nurseries and unadapted germplasm with favorable root architectures, and for assessing management and nutrient practices that promote root growth for maximal SOC sequestration.

OBJECTIVES

The objectives of our team is to: i) Empirically define the optimal ground penetrating radar (GPR)-antenna array for 3D root and soil organic carbon imaging and quantification in high biomass grass systems; and ii) Develop novel 3- and 4-dimensional data analysis methodologies for using GPR for non-invasive crop root and soil C phyto-sequestration 3-D imaging and quantification within a spatially variable soil matrix.

The project will capitalize on: 1) a diverse set of high biomass perennial and annual genotypes of millet, napier grass and sorghum, and 2) three high soil organic carbon multi-decade no-till study sites at Texas A&M AgriLife Research Stations. These experimental systems will provide the required contrast gradients in root and organic matter to evaluate and advance GPR technology.

Fig. 1: Perennial Pearl Millet Napier grass forage: Perennial sorghum 21.56 T C/Ha SOC sequestration

MAIN RESULTS

- Perennial forages and row crops have the potential to sequester significant carbon in the form of high root biomass. In current systems up to 21.56 T C/Ha;
- Longterm no-till studies using high biomass sorghum have shown that increases in SOC is derived almost exclusively by root biomass;
- We have successfully begun to use GPR to phenotype forages and row crops for higher root biomass and SOC sequestration potential.

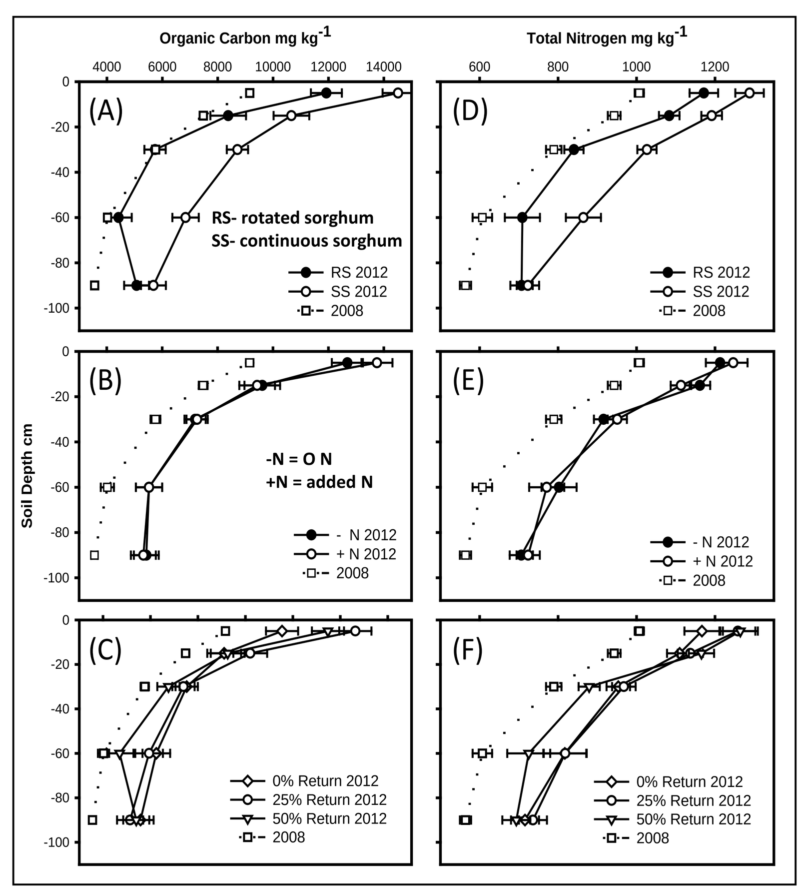


Fig. 2: Changes in Soil Organic C and total N with time indicates SOC accumulation is root driven.

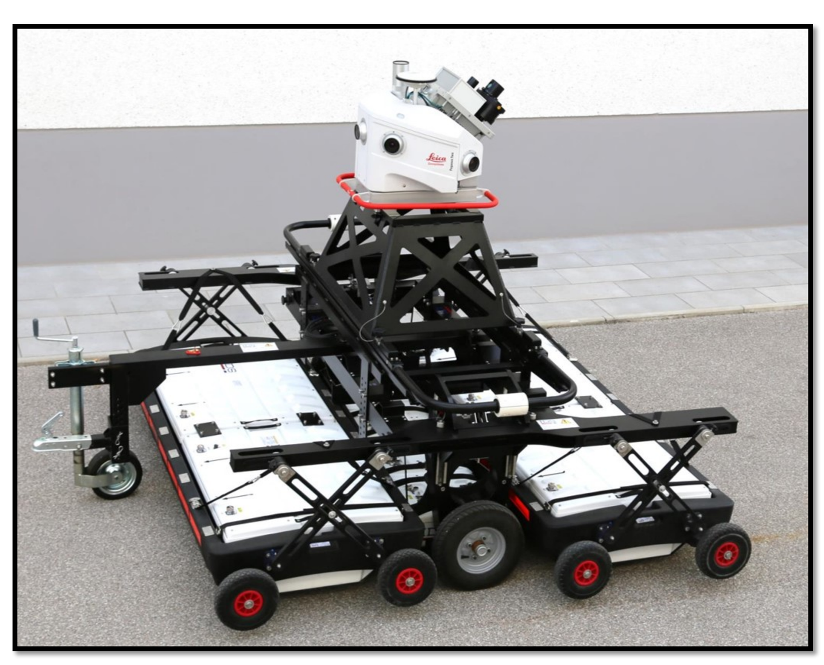
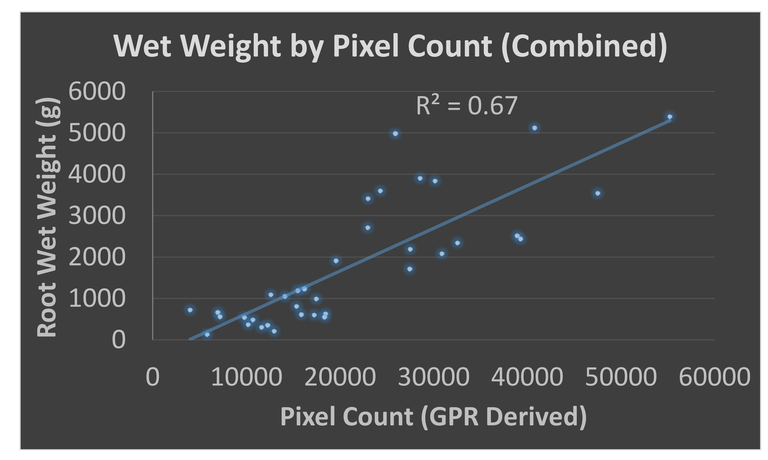
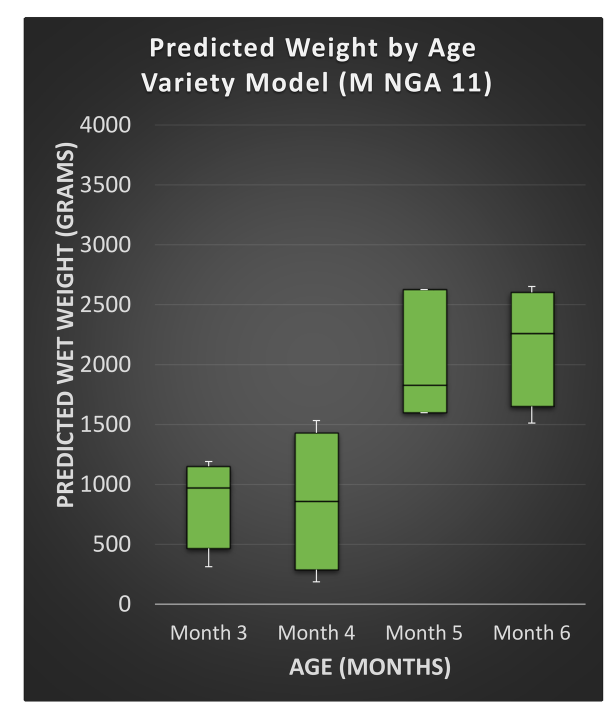


Fig. 3: A prototype multi-array GPR integrated with a Pegasus terrestrial laser scanner for simultaneous 3D imaging of crop root and foliar biomass and architecture



Graph 1: Root wet weight as determined by GPR return pixel counts.



Graph 2: Predicted root biomass using derived allometry

CONCLUSION

Long term no-till studies have shown the increasing SOC sequestration will require a focus on increasing root biomass in cultivated crops;

Additionally, international efforts should focus on incentivizing or regulating farming practices to institutionalize no-till practices as a global effort to increase SOC sequestration;

An increase in SOC to 1.56% on the 5.1 B Ha of global crop land would sequester 80 ppm atmospheric carbon or 167 Gt carbon.