Estimation of Below Ground Biomass in Cassava by Ground Penetrating Radar

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Rationale for the Study

Advantages of early-bulking crop varieties:

- Shorter growth period from planting to harvesting
- Better fit for environments with a short rainy season
- Reduced exposure to biotic and abiotic stresses thus increasing productivity

There is an urgent need to establish non-destructive and rapid root phenotyping tools because root and tuber crops such as cassava are a widely used food source in impoverished areas.

Objectives and Hypothesis

Our hypothesis is that Ground Penetrating Radar (GPR) technology can be used for phenotyping of belowground biomass of cassava under various field conditions and in the context of early root bulking traits. The following objectives are pursued:

- Define the capability of GPR technology to phenotype belowground biomass with regards to early bulking traits in cassava.
- Develop a simple and rapid protocol for predicting root development and root turnover dynamics over time through repeated GPR scans, and explore transferability of the technique to other root and tuber crops.

Methodology

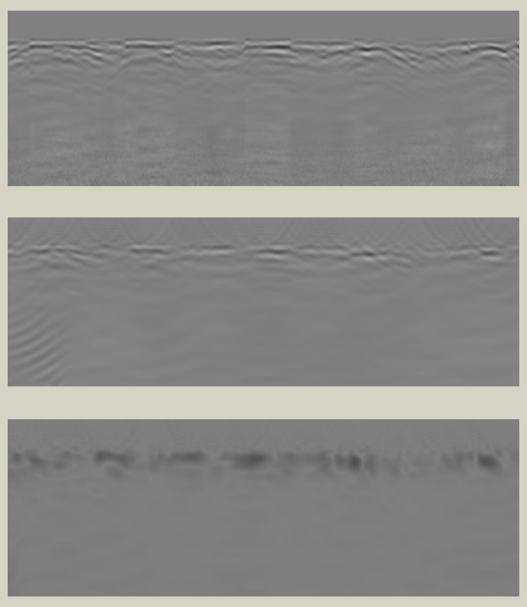
Dry Clay **Wet Clay** **Dry Sand**

Study Design

- 3 varieties of Cassava (HMC-1, SM 1219-1, and M-NGA 11)
- Each variety was located in a specific soil type based on clay content and moisture.
- 4 planting dates (3, 4, 5, and 6 months)
- 5 m by 1 m plot dimensions
- 5 plants per plot (60 plants total)

GPR

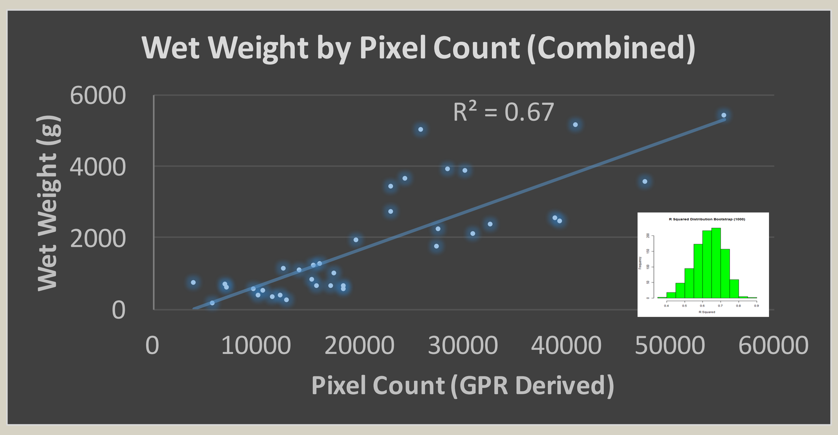
- Detector DUO (IDS North America)
- Dual channel antenna system
- 700 MHz and 250 MHz frequencies
- Directional pulse spacing of .0134 m

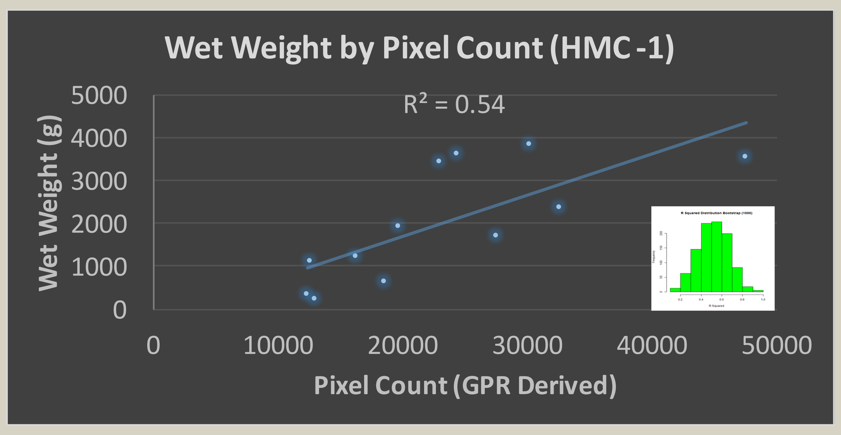


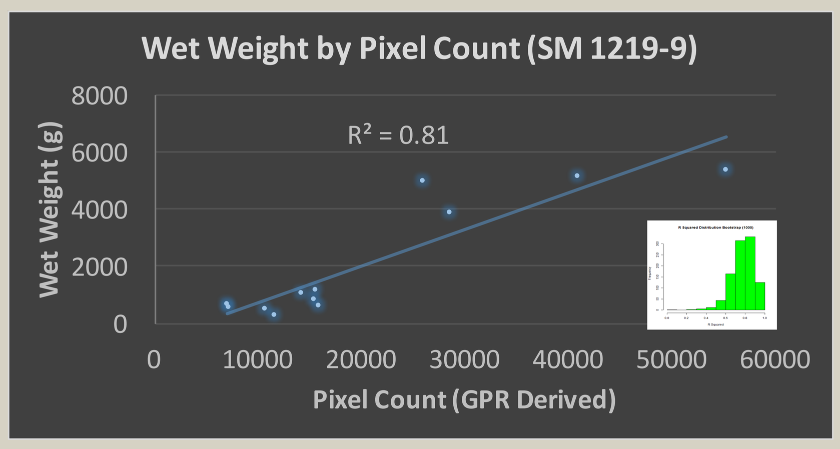
Pixel intensity thresholding was used to identify roots. This is a multi filtering technique with a spectral analysis component and a clustering tool for quantification. Pixel intensity thresholding protocol is described in Delgado et al. (2016).

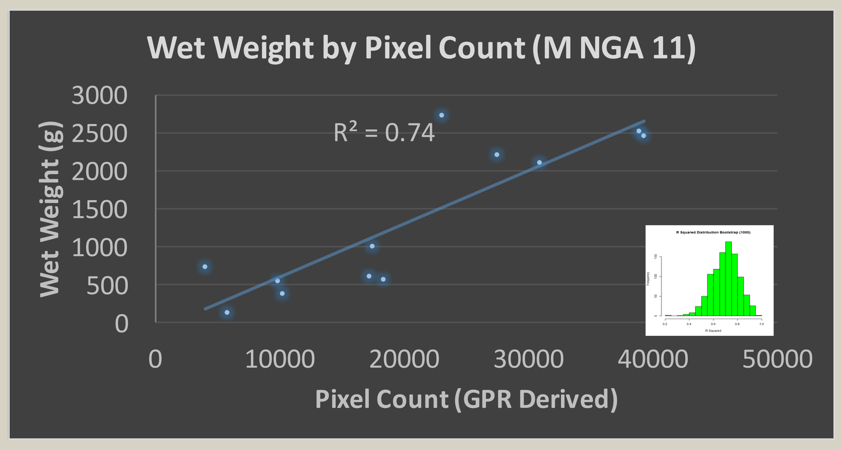
Plants were harvested and weighed for correlation with pixel count values.

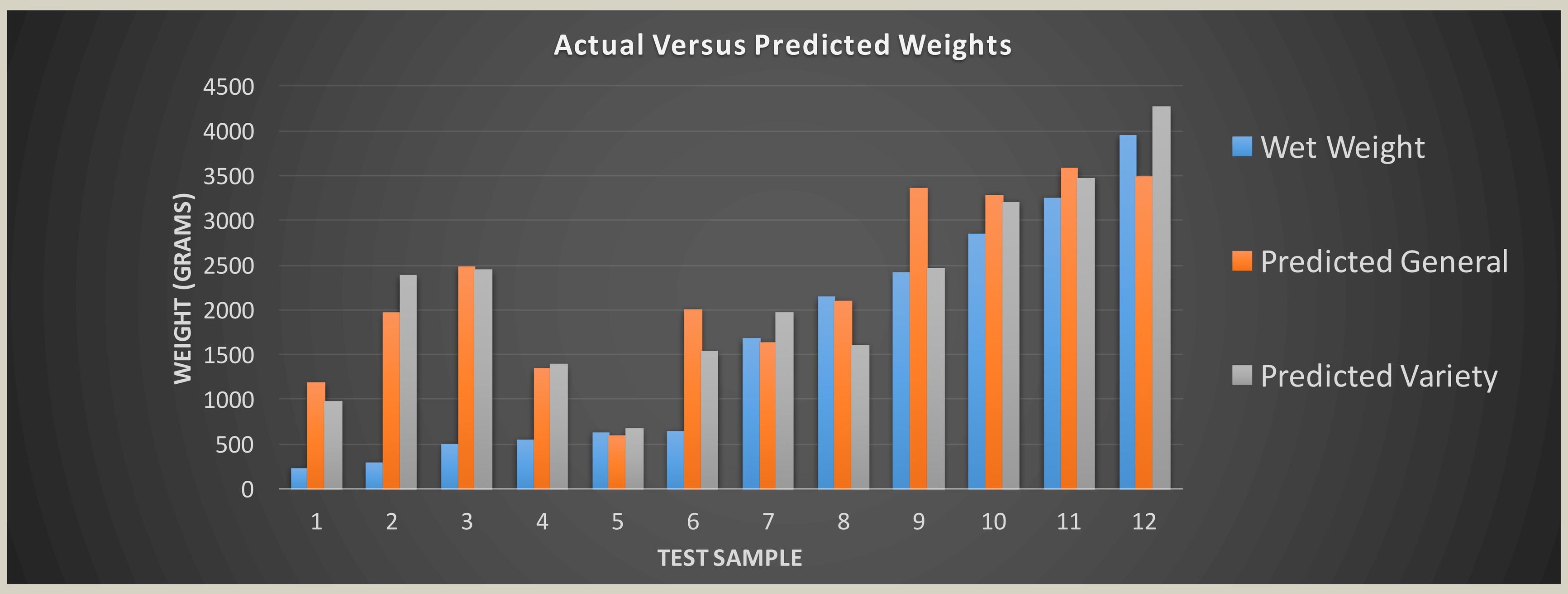
Results

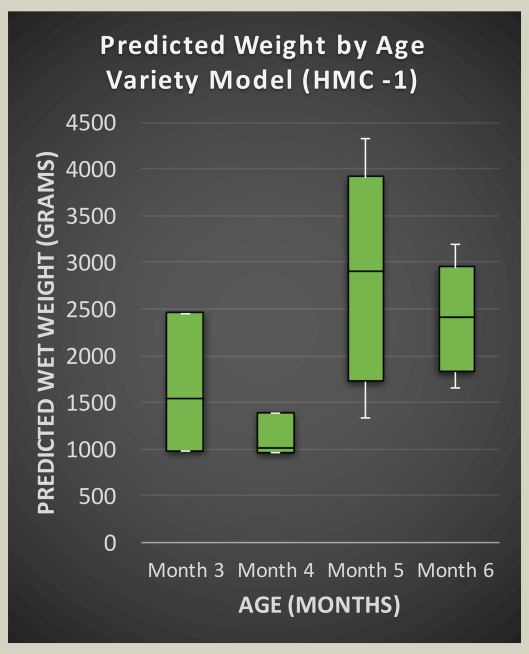


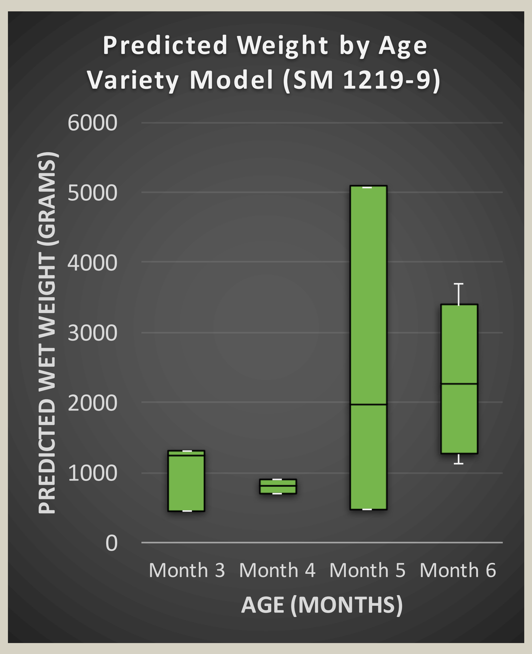


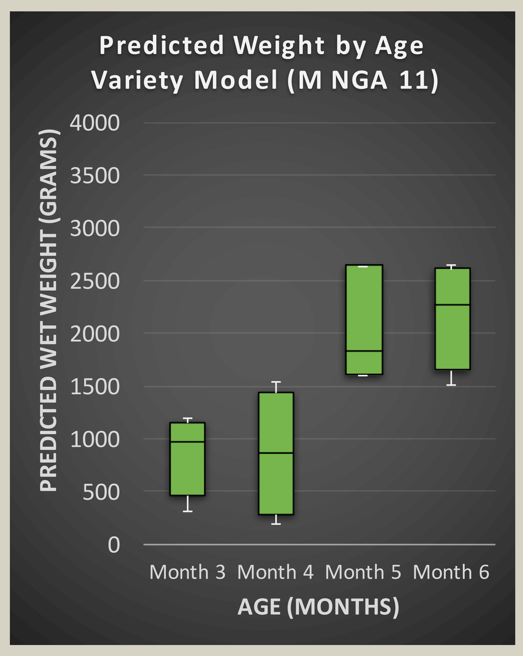












Discussion

- Regression analysis suggests that a generalized (using the data from all three varieties) linear model allows for predictive estimations of root mass in cassava.
- Specific variety linear regressions illustrated the impact of soil type on model predictability.
- The linear model equation is overestimating at early root development ages (months 3 and 4), but begins to normalize as the roots begin to bulk and mature (months 5 and 6).
- All variety models illustrate the expected exponential growth curves of root bulking.

Conclusion

- Linear regression was found to be most significant when measurements were taken in dry sandy soils. This is similar to previous work which elucidated the same relationship when studying root biomass estimations in conifers (Mancuso, 2011).
- Correlations between planting dates and pixel counts as well as correlations between planting date and harvested biomass showed similar trends which strengthen the linear regressions.
- GPR was not able to significantly discern bulking in all soil types, but illustrated the expected trends in root bulking

References

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