Assessing the potential of UAV Spectral Data and Machine learning for Soil Organic Carbon Prediction in Sorghum Fields

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Abstract

Soil Organic Carbon (SOC) fluctuations in agricultural fields play a critical role in determining soil fertility and carbon sequestration. Efficient, non-destructive monitoring of SOC is essential. This study utilized Unmanned Aerial Vehicles (UAVs) and four Machine Learning (ML) algorithms-Multiple Linear Regression (MLR), Partial Least Squares Regression (PLSR), Random Forest (RF), and Xtreme Gradient Boosting (XGB)-to predict SOC levels.

Our research, set at the Danforth Center Field Research Site (FRS), comprised 35 sorghum genotypes in a complete block design. Using a GeoProbe drilling machine, we collected soil cores for compositional analysis through the Haney test. Concurrently, drone-captured multispectral images were processed to create orthomosaic maps and extract features. The ML algorithms effectively predicted SOC levels, with MLR models showing the highest accuracy (RMSE = 7.12 ppm; R = 0.74). We observed variation in SOC among genotypes, suggesting that genotype-specific traits could influence SOC estimation accuracy. Field plots planted with genotypes like SC1345, BTx623, and SAP-133 showed strong predictability with errors below 5%. In contrast, SC283 and SAP-154 had prediction errors exceeding 30%.

UAV-based remote sensing offers promising avenues for soil health assessment, contributing to precision agriculture and sustainable land management. Future studies could benefit from integrating hyperspectral sensors to fully harness this technology's potential.

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