Sampling for Soil Carbon Assessment in Rocky Agricultural Soils

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Why Rocks Matter

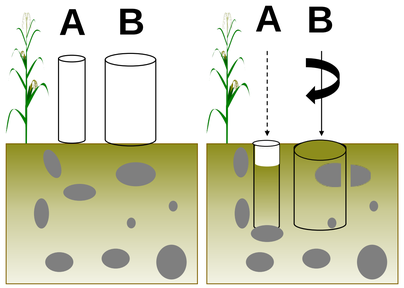


Fig. 1 Schematic of rock obstruction (small diameter core, A), and rock shearing (rotary core, B)

- Soil carbon (C) sequestration is a promising option for climate change mitigation
- Rock fragments (RF, mineral material >2mm) are a major source of error when quantifying soil organic C (SOC) stocks[2] (**Fig. 1**)
- Collecting representative soil samples on rocky soils is not only challenging, but costly[4]

Hypotheses

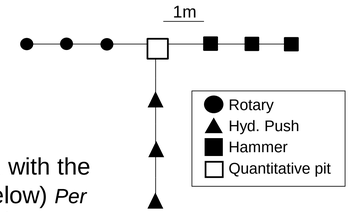
1) **Small diameter soil cores underestimate soil RF and therefore tend to overestimate SOC stock in rocky soils**
2) **Core driving mechanism contributes to underestimates of both bulk density (BD) and RF on rocky soils**
3) **A rotary core equipped with a diamond-tipped bit will reduce sampling bias in rocky soils, and be more cost-efficient than traditional coring methods**

Methods

Study Design:

- **Sampling method** and **calculation approach** effects on SOC stock estimates were compared at four sites along a gradient of RF content: <0.01, 0.14, 0.21, and 0.24 m^3 m^{-3}

Fig. 2 Plot diagram. *Three plots were sampled at each site.*



Sampling Methods:

- Three coring methods were compared with the quantitative pit method (**Plates 1:4,** below) *Per sample area (cm^2) for each method in parentheses*

1. **Quantitative Pit (5000)**

2. **Rotary Core (81.1)**

3. **Hydraulic Push (11.4)**

4. **Hammer Core (7.1)**

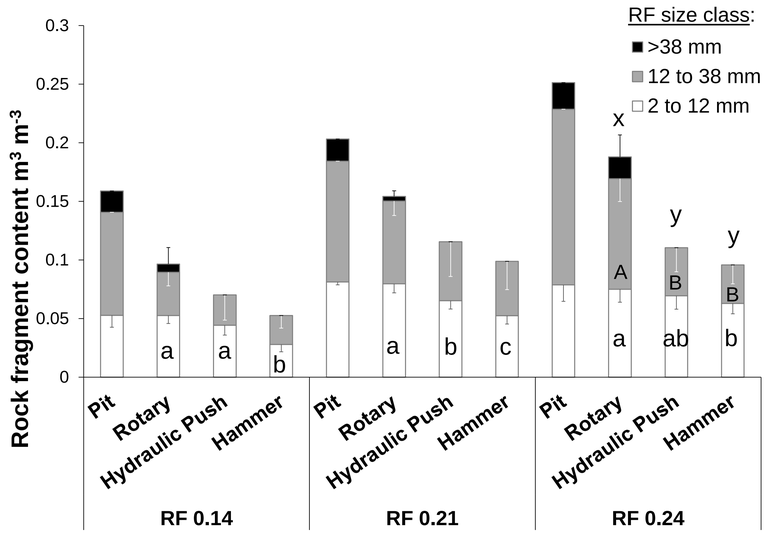
Calculation Methods:

- Fixed-depth versus mass-based approaches
- Two fixed-depth approaches (different estimates of BD):

1) **Core-length** (compensates for soil exclusion)
2) **Hole-depth** (corrects for soil compaction)

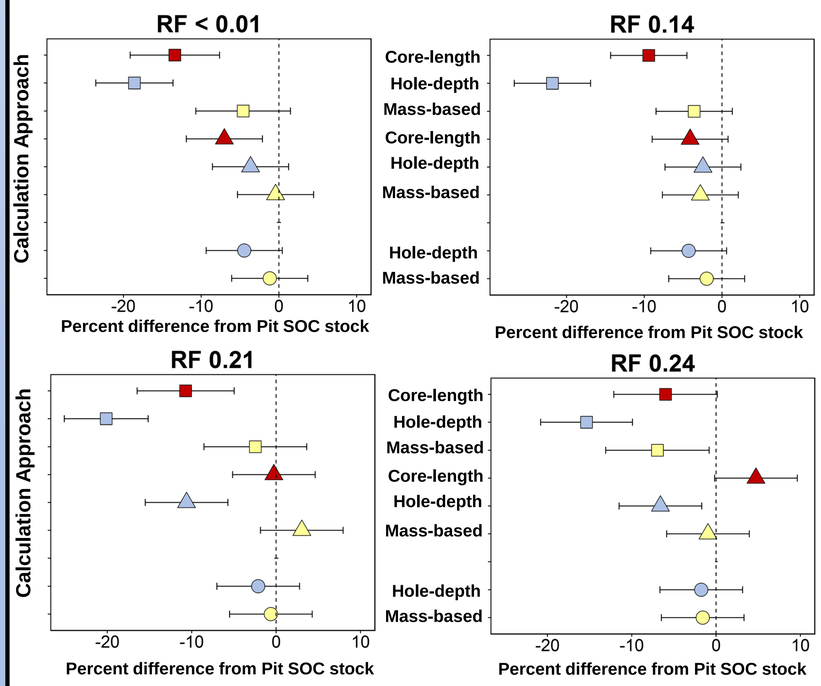
Results

Fig. 3 Size class distribution of RF by percent of total core volume



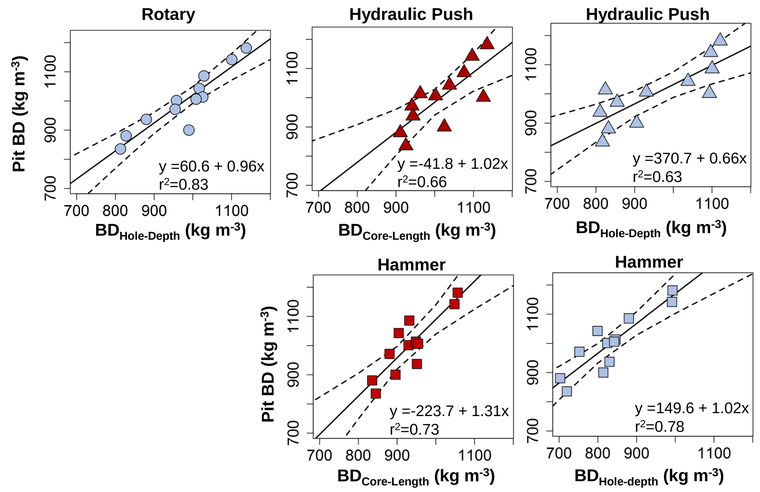
- **All coring methods significantly underestimated RF content at the three rocky sites (14, 21, and 24% RF content)**
- **Smaller diameter cores significantly underestimated small diameter (RF<38 mm) in addition to overall RF content**

Fig. 4 Difference in SOC stock estimates by coring method and calculation method, relative to the quantitative Pit



- **Rotary core SOC stock estimates did not significantly differ from pit estimates at any site**
- **Hammer core SOC stock estimates were significantly different from pit estimates at all sites, except for the core-length estimate at RF 0.24**
- **Mass based stock estimates with coring methods were not significantly different from pit estimates with the exception of the hammer core at RF 0.24**

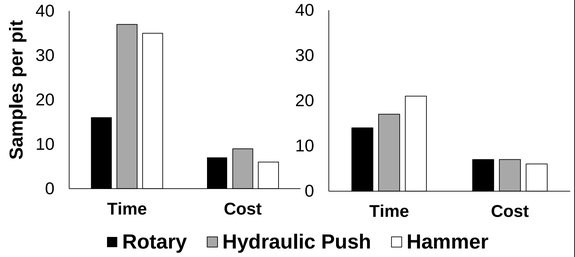
Fig. 5 Quantitative Pit bulk density (BD) predicted by coring method, and calculation method



- **Rotary core BD estimates were closer to pit estimates than the other coring methods**
- **Linear regression models could be used to correct core estimates of BD if calibration data are available**

Fig. 6 Cost and time analysis

- **The rotary core was cost and time competitive at the 24% RF site**
- **Quantitative pits are 7x more costly and 14 to 21x more time consuming even at the high RF site**



Conclusions

- **The rotary core method came closest to pit estimates of RF, BD, and SOC stock at the rocky sites**
- **The hammer method significantly underestimated BD at both rocky and non-rocky sites**
- **Localized regressions could be used to convert BD core data**
- **Hammer or hydraulic push coring method estimates of C concentration can be used at rocky sites with a mass-based approach but require reliable estimates of soil mass obtained with another method**

Future Research:

- Modification of the rotary core apparatus to fit a hydraulically driven sampling rig
- Evaluation of an ensemble-type SOC stock estimation approach utilizing the rotary core or quantitative pit method to establish a reference soil mass, with additional OC samples collected with the hydraulic push or hammer methods to increase spatial coverage of a site

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References: **(1)** Lal, R. 2009. Challenges and opportunities in soil organic matter research. Eur. J. Soil Sci. 60(2): 158–169; **(2)** Goidts, E., B. Van Wesemael, and M. Crucifix. 2009. Magnitude and sources of uncertainties in soil organic carbon (SOC) stock assessments at various scales. Eur. J. Soil Sci. 60(5): 723–7393; **(3)** Rau, B.M., A.M. Melvin, D.W. Johnson, C.L. Goodale, R.R. Blank, G. Fredriksen, W.W. Miller, J.D. Murphy, D.E. Todd, and R.F. Walker. 2011. Revisiting Soil Carbon and Nitrogen Sampling. Soil Sci. 176(6): 273–279

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USDA United States Department of Agriculture National Institute of Food and Agriculture