

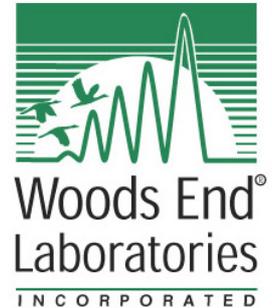


# The Use of Biochar in Agroforestry to Promote Soil Microbial Health, Tree Productivity, and Carbon Sequestration

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## INTERIM SARE REPORT Dec 2022

Arthur's Point Farm, Ghent, New York



# Farm Study Overview



# Methods Implemented

- Focus on soil organic carbon (SOC) with high combustion at 900°C
- Distinguish topsoil from depth
- Overall Soil Health (Solvita Nexus) for topsoil samples
  - Microbial scan
  - Leaf tissue tests
- Design enables statistical comparisons



Sample Farm

Account / Sample ID:	1111 / 11897.2
Rainfall / Zone:	20 / COLORADO PLATEAU
Soil Orders:	Afisol-Ustalfs / Entisol-Psammets / *
Your Sample:	Soil: C Field C Clay
Received / Reported:	11/Feb/22   18/Feb/22
Intended Crop:	General Crops

Soil Health Panel	Units	RANKING:
Microbial Rate	ppm	125.6 High
Solvita Response	( 0 - 5 ) ppm	4.66 High
Soil Amino-N	ppm	428 VHigh
Crumb Aggregates	Vol %	26 Medium
Scoop Bulk Density	g/cc	0.96 Optimal
Organic Matter	%	6.343 Med-High

Nutrients as: lb/a	Interpretative Guidelines			Est Carbon:
	N	P2O5	K2O	lb/a
Soil Supply:	202	928	130	57,438
Crop Use:	75	35	35	
Difference:	0	0	0	
Min Annual Need	25	26	230	Est EEC, meq
Other Nutrients:	OK	Excess	Normal	*Note



**OVERALL FERTILITY SCORE**  
YOUR VALUE IS BLACK. RED LINE IS REGION-EXPECTED TARGET



**SOIL HEALTH SCORE**  
YOUR VALUE IS BLACK POINTER.  
BLUE IS Minimum and RED is Optimal Target

Green Manure/Cover Crop Recommendations

Types of inter-planting Blends Suggested:

100% Grass/Non-Legume

Color Key for Nutrient Fertility				
Very Low	Normal	Elevated	Warning	

(warning may be either too high or too low)

Analysis	Units	RESULT
Climate Zone at this Location	ZONE	6
Nitrogen as readily soluble NO3-N	ppm	18
Est. Seasonal Biological N-Release	lb/a	165
PMN (Avail. + N-Min) Nitrogen Potential	lb/a	202
Likelihood of added N-Response	Rating	Low

Extractable Nutrients		
Phosphorus - Extractable P	mg kg	209
Phosphorus - Water Sol Equilibrium P	mg kg	3.1
Potassium - Extractable K	mg kg	56
Calcium - Extractable Ca	mg kg	8765
Magnesium - Extractable Mg	mg kg	241
Sodium - Extractable Na	mg kg	90

Rating Factors		
Nutrient Index, Scale 0 - 100	Rating	100%
Most Limiting Factor		None
Cation Balance (Molar Ratio: K + [Ca + Mg] )	Optimal	0.3%

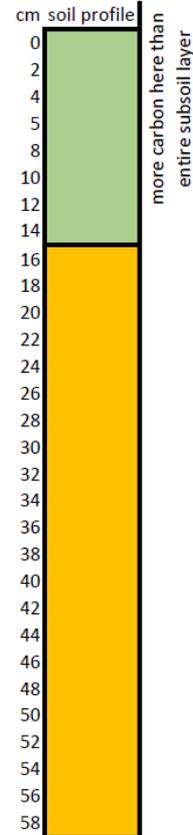
Other Factors		
pH in water 1:1	Unit	8.020
Optional test (buffer pH)	Unit	7.260
Water Soluble Carbon	mg kg	142
Water Soluble C:N (WSOC:NO3-N)	Unit	8
Aluminum, Extractable	mg kg	120
Est. Limestone Content	dry %	NT

Soil Test Form 201-a Copyright ©2021 Woods End Laboratories Inc.  
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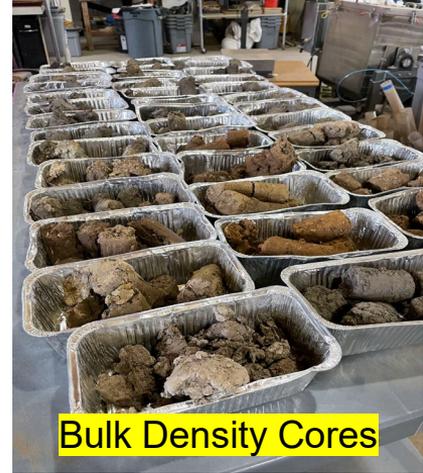
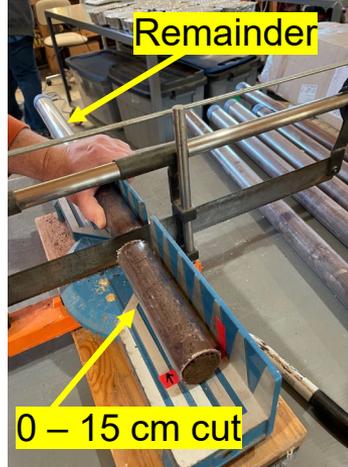


# Completed Test Metrics (Soil & Deep Core Samples)

- Soil Health, Biochemistry and Nutrients assessed for 60 sample points at 6" depth
- *Deep carbon sampling*, 40 samples
  - A. Topsoil considered as 0 - 15 cm
  - B. Average Max Attained Depth : 58 cm (see inset)
- Carbon and Bulk Density for each (A, B)



# Soil Sample Processing



## Hydraulic Soil Cores sent to lab and cut at 15 cm and *remainder*

- Air-dry entire core sections for weight capture
- Measured total soil dry weight versus tube volume for Bulk density
- Separated stone fraction from soil
- Calculated particle density of each fraction
- Measured Total-C \* on soil fraction less stone fraction
- Calculated carbon stock correcting for soil density

# Challenges on the way

soil weight (g)	soil dried weight (g)	Moisture %	BD g/cc	Rocks (g)	% soil	Top Tube Volume	Top Rock Volume	Corrected BD g/cc
359.53	255.37	30.05	1.120	130.16	46.33	216.44	49.12	0.671

- Significant stones in all bulk density samples
- *In some cores, less than 50% is soil*
- Carbon measured only in soil fraction.

Original Sample

Stones Portion

sieved soil for testing



# Summary Baseline Results

- *Mass per Area by Layer*
  - Separate soil from stones (!)
  - Correct BD and analyze TOC soil
  - Compare topsoil to depth (layer)
  - Huge difference in layers
  - Compare topsoil by 2 methods

Topsoil 0–15 cm Results:

*Avg in Core samples:*

**1.32 ± 0.34 %TOC**

*Avg in Fertility samples:*

**1.26 ± 0.38 %TOC**

Remainder (15 ~ 60cm)

*Avg. in core samples:*

**0.19% ± 0.11 %TOC**

Close agreement by 2 different  
sampling methods (n=40 vs n=60)

## Topsoil 0 - 15 cm Samples

Apparent Bulk Density, g/cc

**1.443**

Corrected Bulk Density after stone removal

**1.095**

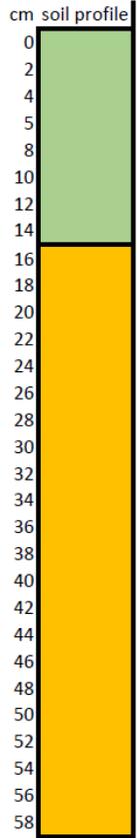
## Remainder to Depth Samples

Apparent Bulk Density, g/cc

**1.876**

Corrected Bulk Density after stone removal

**1.121**



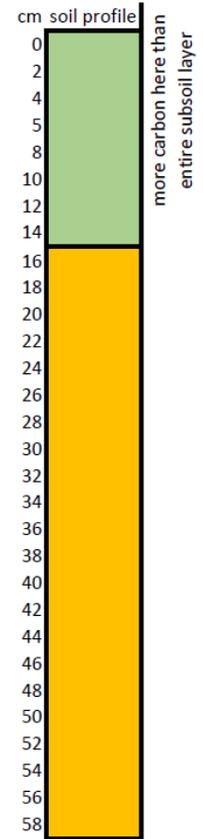
# Summary Carbon Stock

- Depth stratification of C is great as is variability between samples
- Of total carbon at depth, 60% is in the top 6" (15 cm) layer
- Suggested: *not necessary to examine carbon below 15 cm since quantities likely to be very low with very high variability*

0 – 15 cm Avg. SOC stock is **17 t/ha**

## CARBON STOCK FINDINGS

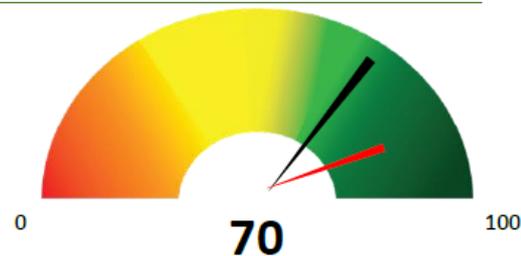
Remainder Depth SOC is **11 t/ha**



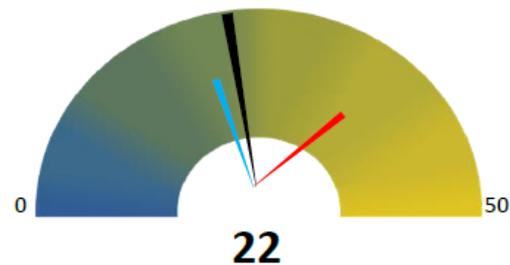
# Overview – Field Soil Health and the Bigger Picture

- Average fertility 70% of target expected for region & soil
  - Carbon slightly low for NE soils
  - pH is optimal; Ca, Mg adequate
  - N-min is moderate and K-potassium the most likely deficient crop nutrient element
- Soil Health Index (7 indicators) 60% of target
  - Lower than normal OM and carbon means improvements can be expected
  - Low soil crumb (aggregate) structure possibly linked to structureless Inceptisols
- Microbial indicators not yet interpreted; include F:B ratio; Trichoderma, actinomycetes
- Plant leaf tissue total nitrogen close to normal and varied significantly across zones. Difficult to sample young trees.

*AVERAGE of 60 samples*



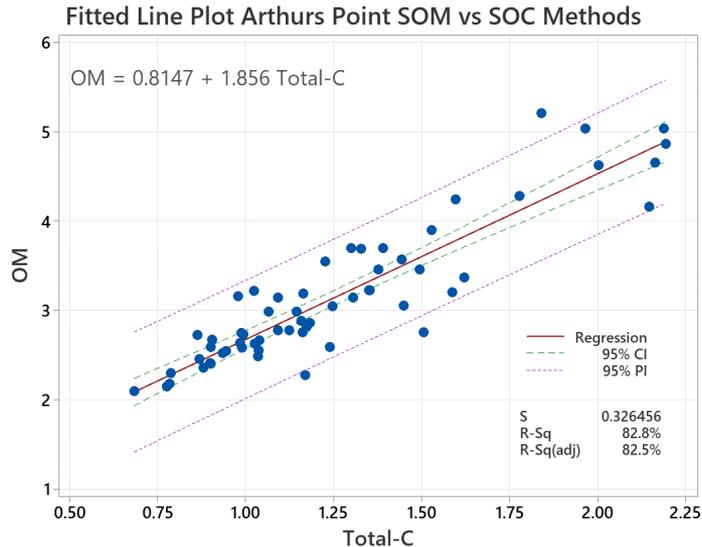
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# Results Details

## Traditional Organic Matter methods closely correlated to modern carbon combustion



## Baseline Results: No significant differences in TOC between 5 treatments in layout \*

TR ID	N	Mean	Grouping
1.	ComBCh	12	1.340 A
2.	CmAdBT	12	1.3113 A
3.	ConCom	12	1.249 A
4.	ComAdd	12	1.248 A
5.	CmAdBc	12	1.1353 A

Grouping Information Using the Tukey Method and 95% Confidence

*Means that do not share a letter are significantly different.*

*\* It is desirable that baseline, start conditions exhibit no significant differences between treatments; however large variability across field will compromise ability to distinguish small differences*