Understanding and Using Soil Test Results: Soil Fertility vs Soil Health

Jonathan L. Deenik

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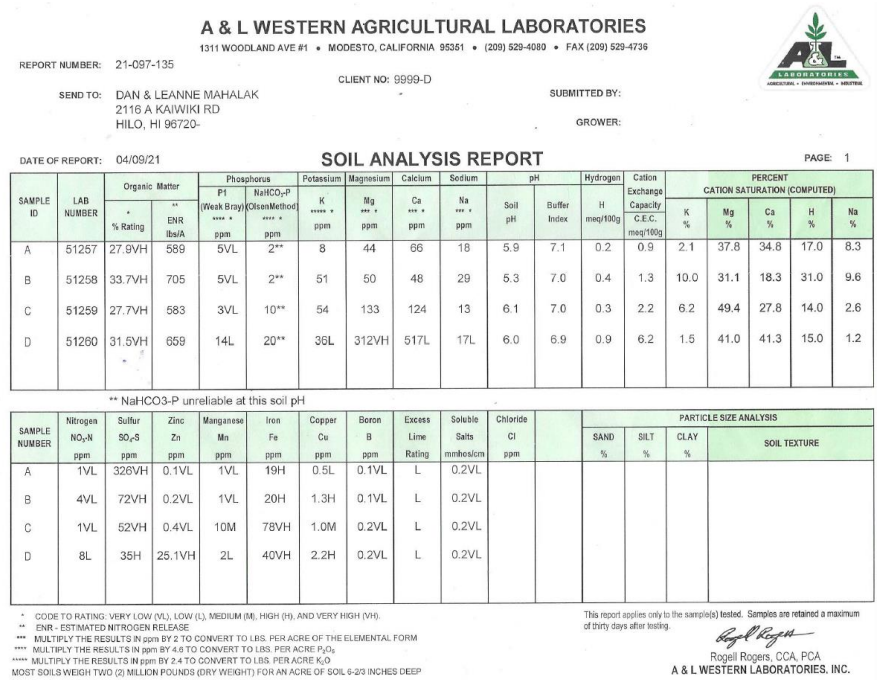

A & L WESTERN AGRICULTURAL LABORATORIES

1311 WOODLAND AVE #1 • MODESTO, CALIFORNIA 95351 • (209) 529-4080 • FAX (209) 529-4736

REPORT NUMBER: 21-097-135 CLIENT NO: 9999-D

SEND TO: DAN & LEANNE MAHALAK
2116 A KAIWIKI RD
HILO, HI 96720-

SUBMITTED BY:

GROWER:

DATE OF REPORT: 04/09/21

SOIL ANALYSIS REPORT

PAGE: 1

SAMPLE ID	LAB NUMBER	Organic Matter		Phosphorus		Potassium	Magnesium	Calcium	Sodium	pH		Hydrogen	Cation Exchange	PERCENT CATION SATURATION (COMPUTED)				
				P1 (Weak Bray)	$NaHCO_3$-P (Olsen Method)	K	Mg	Ca	Na	Soil	Buffer	H	Capacity C.E.C.	K	Mg	Ca	H	Na
		% Rating	ENR lbs/A	**** * ppm	**** * ppm	***** * ppm	*** * ppm	*** * ppm	*** * ppm	pH	Index	meq/100g	meq/100g	%	%	%	%	%
A	51257	27.9VH	589	5VL	2**	8	44	66	18	5.9	7.1	0.2	0.9	2.1	37.8	34.8	17.0	8.3
B	51258	33.7VH	705	5VL	2**	51	50	48	29	5.3	7.0	0.4	1.3	10.0	31.1	18.3	31.0	9.6
C	51259	27.7VH	583	3VL	10**	54	133	124	13	6.1	7.0	0.3	2.2	6.2	49.4	27.8	14.0	2.6
D	51260	31.5VH	659	14L	20**	36L	312VH	517L	17L	6.0	6.9	0.9	6.2	1.5	41.0	41.3	15.0	1.2

** NaHCO3-P unreliable at this soil pH

SAMPLE NUMBER	Nitrogen NO_3-N	Sulfur SO_4-S	Zinc Zn	Manganese Mn	Iron Fe	Copper Cu	Boron B	Excess Lime	Soluble Salts	Chloride Cl		PARTICLE SIZE ANALYSIS SAND	SILT	CLAY	SOIL TEXTURE
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	Rating	mmhos/cm	ppm		%	%	%	
A	1VL	326VH	0.1VL	1VL	19H	0.5L	0.1VL	L	0.2VL						
B	4VL	72VH	0.2VL	1VL	20H	1.3H	0.1VL	L	0.2VL						
C	1VL	52VH	0.4VL	10M	78VH	1.0M	0.2VL	L	0.2VL						
D	8L	35H	25.1VH	2L	40VH	2.2H	0.2VL	L	0.2VL						

* CODE TO RATING: VERY LOW (VL), LOW (L), MEDIUM (M), HIGH (H), AND VERY HIGH (VH).
** ENR - ESTIMATED NITROGEN RELEASE.
*** MULTIPLY THE RESULTS IN ppm BY 2 TO CONVERT TO LBS. PER ACRE OF THE ELEMENTAL FORM
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MOST SOILS WEIGH TWO (2) MILLION POUNDS (DRY WEIGHT) FOR AN ACRE OF SOIL 6-2/3 INCHES DEEP

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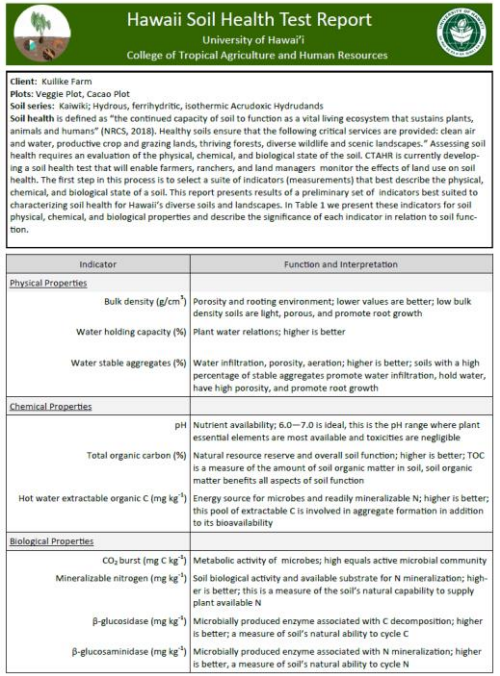

Hawaii Soil Health Test Report

University of Hawai'i
College of Tropical Agriculture and Human Resources

Client: Kuilike Farm
Plots: Veggie Plot, Cacao Plot
Soil series: Kaiwiki; Hydrous, ferrihydritic, isothermic Acrudoxic Hydrudands
Soil health is defined as "the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals and humans" (NRCS, 2018). Healthy soils ensure that the following critical services are provided: clean air and water, productive crop and grazing lands, thriving forests, diverse wildlife and scenic landscapes." Assessing soil health requires an evaluation of the physical, chemical, and biological state of the soil. CTAHR is currently developing a soil health test that will enable farmers, ranchers, and land managers monitor the effects of land use on soil health. The first step in this process is to select a suite of indicators (measurements) that best describe the physical, chemical, and biological state of a soil. This report presents results of a preliminary set of indicators best suited to characterizing soil health for Hawaii's diverse soils and landscapes. In Table 1 we present these indicators for soil physical, chemical, and biological properties and describe the significance of each indicator in relation to soil function.

Indicator	Function and Interpretation
Physical Properties	
Bulk density (g/cm^{-3})	Porosity and rooting environment; lower values are better; low bulk density soils are light, porous, and promote root growth
Water holding capacity (%)	Plant water relations; higher is better
Water stable aggregates (%)	Water infiltration, porosity, aeration; higher is better; soils with a high percentage of stable aggregates promote water infiltration, hold water, have high porosity, and promote root growth
Chemical Properties	
pH	Nutrient availability; 6.0—7.0 is ideal, this is the pH range where plant essential elements are most available and toxicities are negligible
Total organic carbon (%)	Natural resource reserve and overall soil function; higher is better; TOC is a measure of the amount of soil organic matter in soil, soil organic matter benefits all aspects of soil function
Hot water extractable organic C (mg kg^{-1})	Energy source for microbes and readily mineralizable N; higher is better; this pool of extractable C is involved in aggregate formation in addition to its bioavailability
Biological Properties	
CO_2 burst (mg C kg^{-1})	Metabolic activity of microbes; high equals active microbial community
Mineralizable nitrogen (mg kg^{-1})	Soil biological activity and available substrate for N mineralization; higher is better; this is a measure of the soil's natural capability to supply plant available N
β-glucosidase (mg kg^{-1})	Microbially produced enzyme associated with C decomposition; higher is better; a measure of soil's natural ability to cycle C
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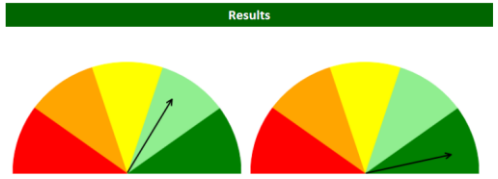


Indicator	Plot		
Substrate Availability Properties	Veggie Plot	Cacao Plot	Median (n=117)
Hot water extractable organic C (mg kg^{-1})	1156	4504	927.62
CO_2 burst (mg C kg^{-1})	242.62	857.56	171.31
Mineralizable nitrogen (mg kg^{-1})	54.68	247.34	44.47
Water holding capacity (%)	152.00	352.59	145.20
Subscore for substrate availability (%)	69	94	
Master Soil Properties			
Water stable mega aggregates (%)	28.18	7.47	18.23
pH	6.36	6.73	6.24
Total organic carbon (%)	16.39	24.75	7.53
Subscore for master soil properties (%)	69	88	
Biological Activity Properties			
β-glucosidase (mg kg^{-1})	60.84	218.33	100.17
β-glucosaminidase (mg kg^{-1})	19.92	92.08	51.30
Subscore for biological activity properties (%)	17	89	
Other			
Bulk density (g cm^{-3})	0.42	0.35	0.55
Soil Health Score			
	67%	93%	

Soil Fertility

Managing soil nutrient status in soils to create optimum conditions for plant growth in relation to agricultural sustainability and environmental protection. (B.R. Singh, 2002)

Soil fertility depends on:

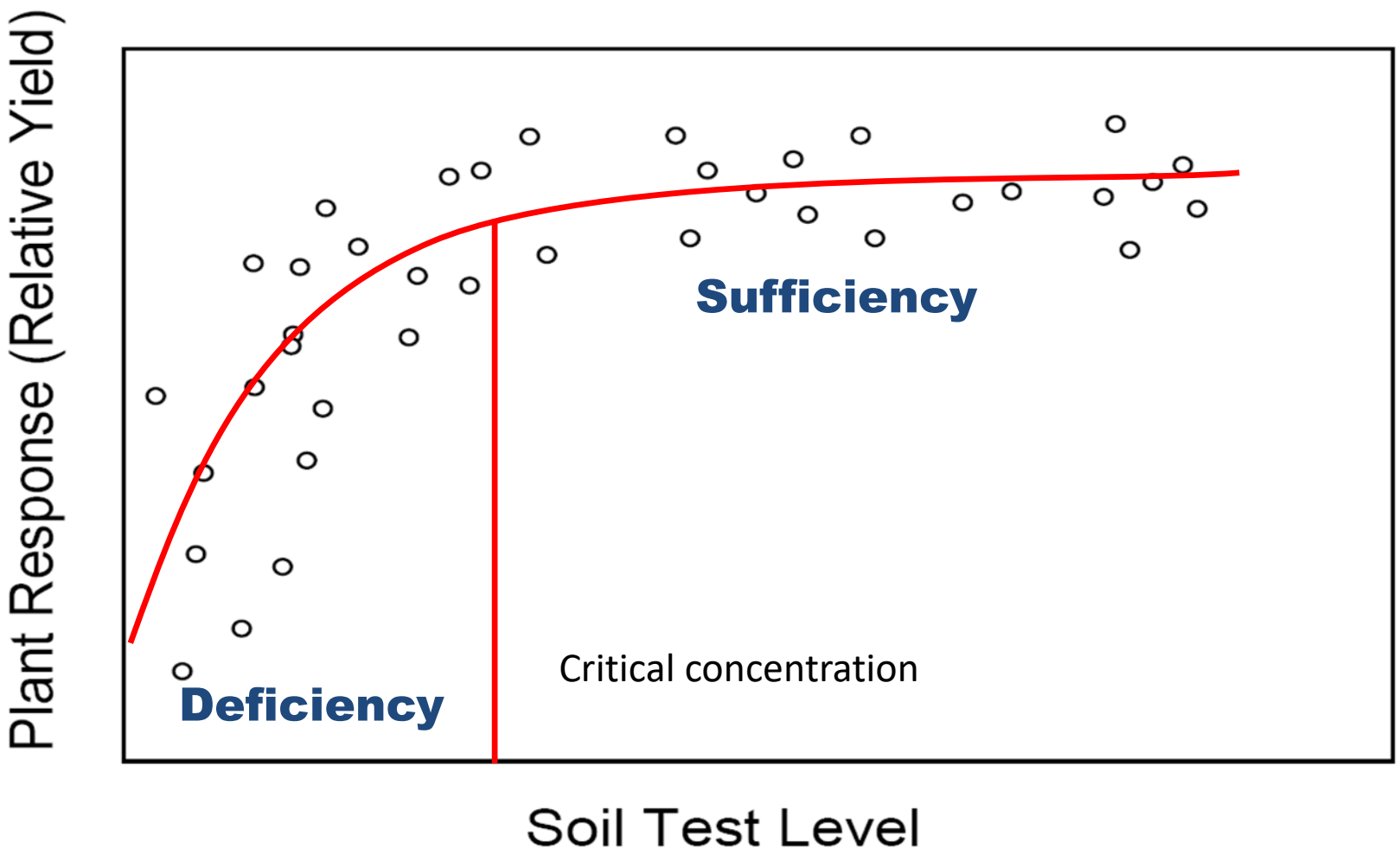
- Inherent soil properties (physical and chemical properties, clay mineralogy)
- Soil organic matter
- Climate (soil moisture & temperature)

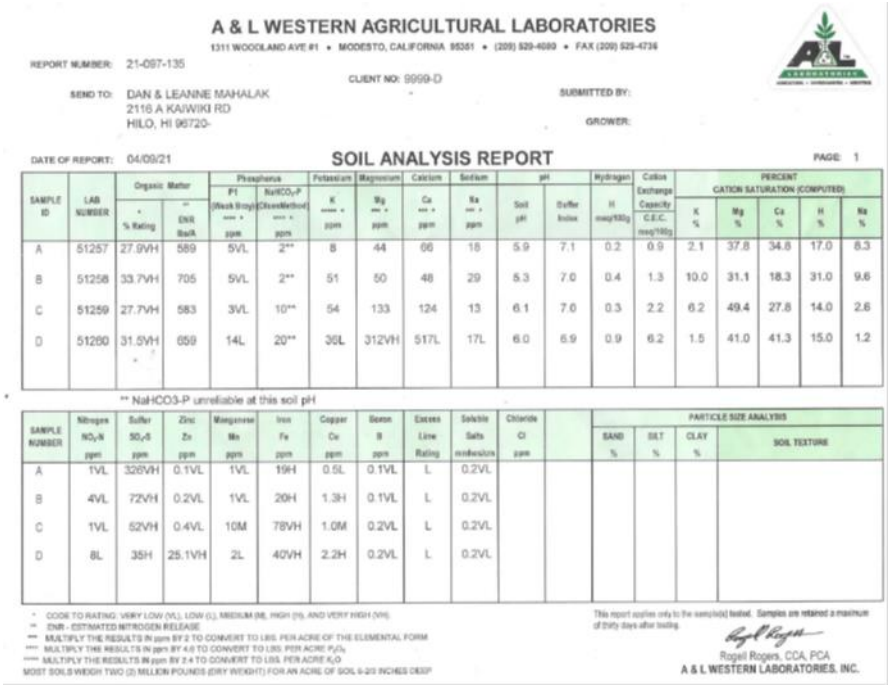
Soil Fertility Test

1. *Diagnosis*

   Rapid chemical analyses to assess the plant-available nutrient status, salinity, and elemental toxicity of a soil in relation to crops.

2. *Interpretation*
   - Deficiency – sufficiency – excessive
   - Non-toxic - toxic
3. *Recommendation*
   - What to add?
   - How much to add?
   - When to add?
   - Where to place?





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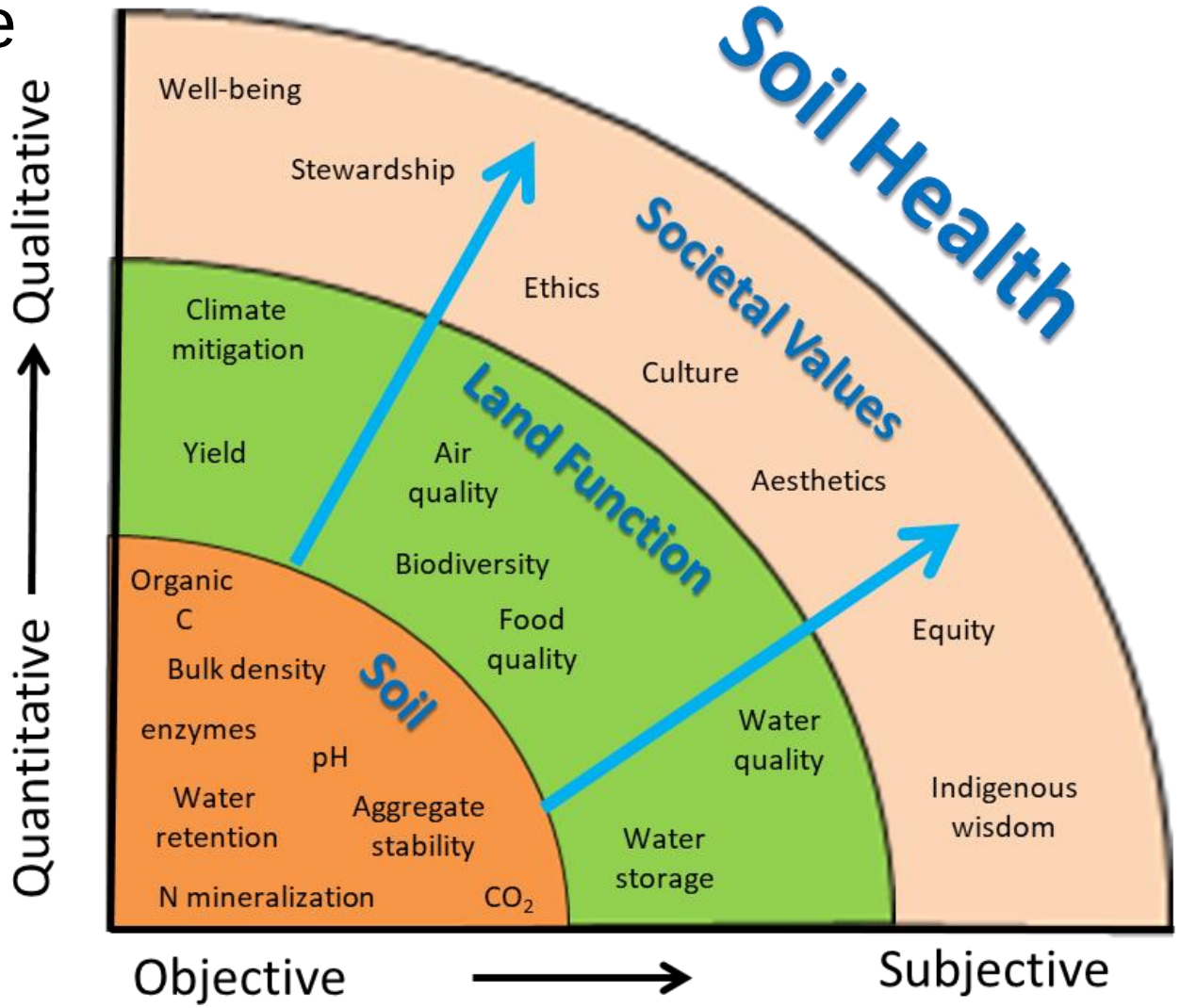
Soil Health

- Soil health is a metaphor with the following elements:
  - *Functionality*: promotes utility and processes that maintain integrity and stability of biosphere
  - *Vitality*: soil is a living system, a complex assemblage of numberless and mostly nameless biota mediating basic soil processes and plant interactions
  - *Sustainability/Resilience*: a soil's enduring capacity to promote its myriad functions in the face of disturbance



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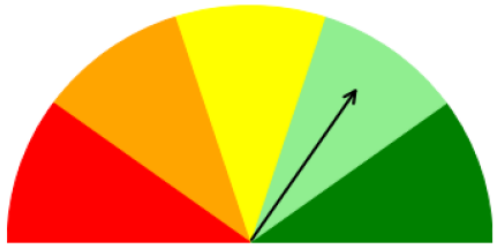
Results



69%

high

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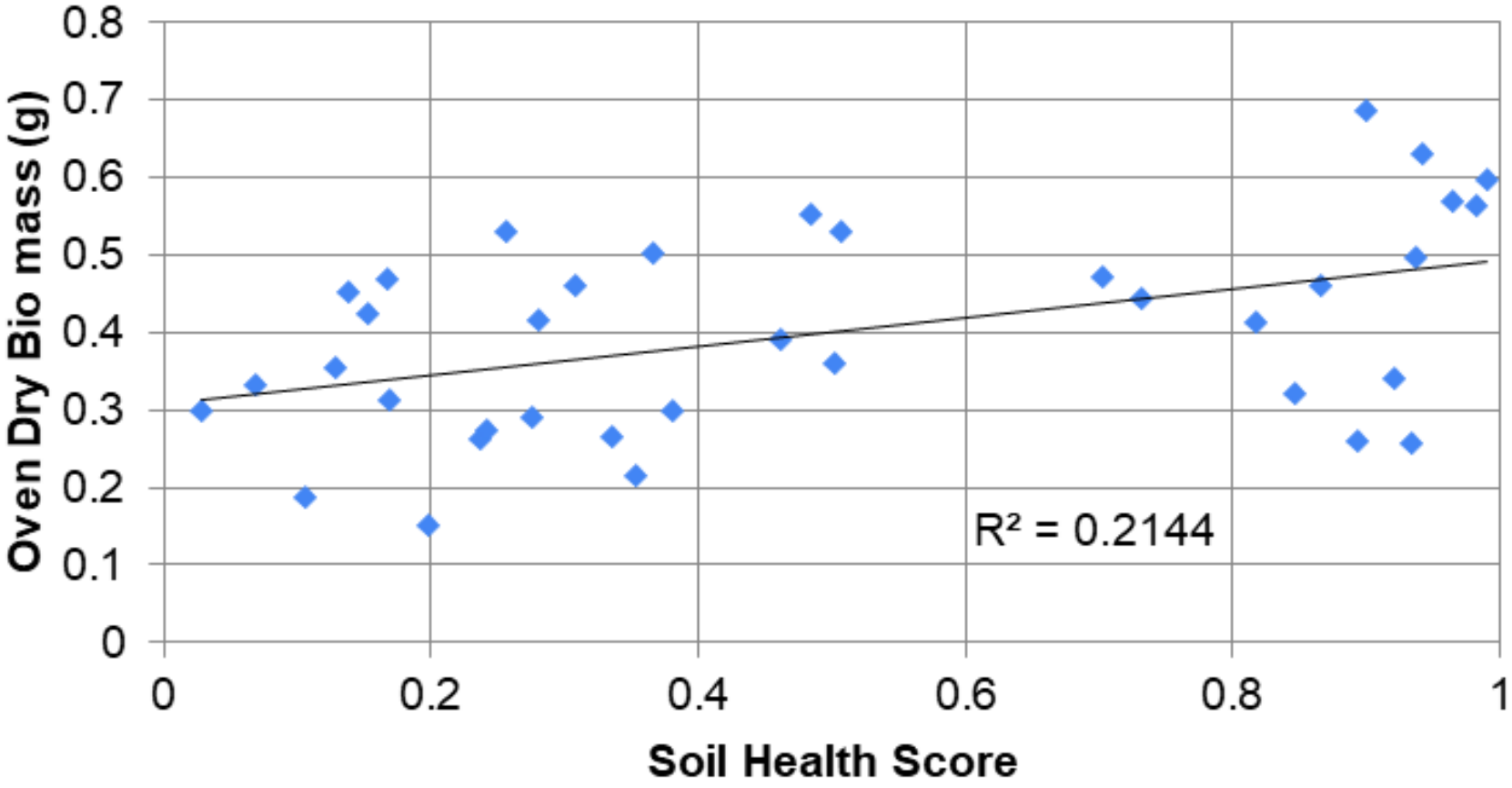
Mineralizable nitrogen ($mg\ kg^{-1}$)	94.16	44.47
Water holding capacity (%)	180.05	145.20
Subscore for substrate availability (%)	69	
Master Soil Properties		
Water stable mega aggregates (%)	7.04	18.23
pH	4.86	6.24
Total organic carbon (%)	13.94	7.53
Subscore for master soil properties (%)	68	
Biological Activity Properties		
β-glucosidase ($mg\ kg^{-1}$)	98.31	100.17
β-glucosaminidase ($mg\ kg^{-1}$)	53.78	51.30
Subscore for biological activity properties (%)	59	
Other		
Bulk density ($g\ cm^{-3}$)	0.22	0.55
Soil Health Score		
	69%	

- Does crop performance respond to a soil health score?



This is a critical area of inquiry that is needed to help guide how we best use the results of a soil health test.

Kawiki Food Forest

Soil: highly weathered volcanic ash soil

DATE OF REPORT: 04/09/21

SOIL ANALYSIS REPORT

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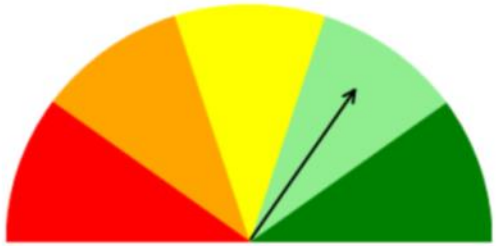

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Biological Activity Properties		
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β-glucosaminidase (mg kg^{-1})	53.78	51.30
Subscore for biological activity properties (%)	59	
Other		
Bulk density (g cm^{-3})	0.22	0.55
Soil Health Score		
	69%	

Interpretation

Soil Fertility

- Soil has very low nutrient status – especially P, Ca, and K

Soil Health

- Soil is rich in organic matter
- Soil health tied to soil organic matter

Recommendation

Soil Fertility

- Manure applications to build soil P and Ca
- Sulfate of potash to raise soil K

Soil Health

- Manure will likely improve soil health score

Kuilike Farm

Soil: highly weathered volcanic ash soil

Location: Upper orchard

	mmhos/cm		ppm, ug/g			
DESCRIPTION	pH	EC	P	K	Ca	Mg
North Top 8 -#1	4.7		22	116	58	45
South Top 8 #1	4.8		10	58	34	47
South 8 - 24	5.0		8.0	17	37	35
South Top 8 #2	4.9		19	54	41	45
North Top 8 #2	4.7		24	132	53	45
North 8 - 24	4.9		10	74	39	30
Center 8 #1	5.0		20	70	65	40
Center 8 #2	4.9		22	80	68	37
Center 8 - 24	4.9		17	39	38	20

Sample Information

Job Control No:	15-050702-001	Map Unit:		Plant Grown:	
Sample Label:	UPPER GARDEN	Soil Series:		Plant to be gro	
Date Received:	9/10/2014	Soil Category:	LIGHT SOIL	Can you till 4~(	
Send Copy To		Soil Depth (in):		Test Results C	
Elevation (ft.):		Latitude:		Longitude:	

Test Results and Interpretation

LIGHT SOIL

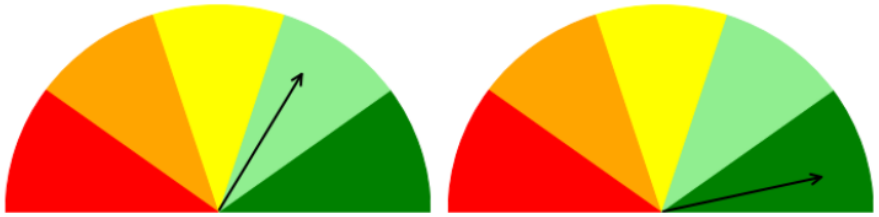
			INTERPRETATION		
Soil Analysis	Results	Expected	Very Low	Low	Sufficient
_pH	6	6.15			
P_ppm	74	67.5			
K_ppm	54	300			
Ca_ppm	2649	3500			
Mg_ppm	270	700			

- Soil is very acid
- All nutrient levels very low

- Soil pH and Ca sufficient
- P may be on the low side
- K very low

Hawai‘i Soil Health Test

Results



67%

high

93%

very high

Indicator	Plot		
Substrate Availability Properties	Veggie Plot	Cacao Plot	Median (n=117)
Hot water extractable organic C (mg kg^{-1})	1156	4504	927.62
CO_2 burst (mg C kg^{-1})	242.62	857.56	171.31
Mineralizable nitrogen (mg kg^{-1})	54.68	247.34	44.47
Water holding capacity (%)	152.00	352.59	145.20
Subscore for substrate availability (%)	69	94	
Master Soil Properties			
Water stable mega aggregates (%)	28.18	7.47	18.23
pH	6.36	6.73	6.24
Total organic carbon (%)	16.39	24.75	7.53
Subscore for master soil properties (%)	69	88	
Biological Activity Properties			
β-glucosidase (mg kg^{-1})	60.84	218.33	100.17
β-glucosaminidase (mg kg^{-1})	19.92	92.08	51.30
Subscore for biological activity properties (%)	17	89	
Other			
Bulk density (g cm^{-3})	0.42	0.35	0.55
Soil Health Score			
	67%	**93%**	

Take Home

- Soil fertility and soil health testing are different and both useful
- A soil fertility test provides a diagnosis from which a clear and actionable recommendation can be made
- A soil health test is more nuanced and the results are highly influenced by soil organic matter status
- Soil health testing is useful to monitor trends over time related to soil management strategies
- Soil health is not directly correlated with crop yields