TESTING FOR SOIL HEALTH

CO2-RESPIRATION AND SOIL HEALTH NUTRIENT TOOL

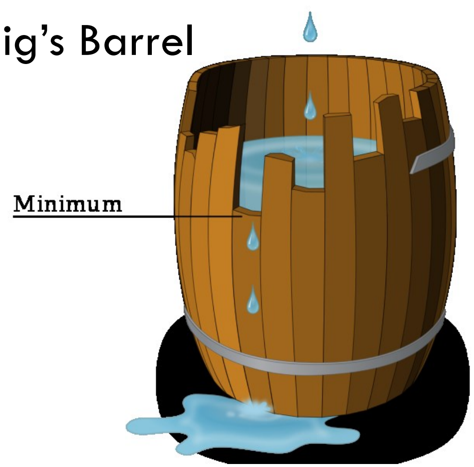
Farm Foundation®

Will Brinton, Ph.D. Director and Founder
Woods End Farm & Laboratories – Research Farm (above)

Humus biology left out from the start

- "There is not a shadow of proof that humus exerts any influence on the growth of plants … Humus in soil does not yield the smallest nourishment to plants… This belief has deprived us of our best guide to *rational agriculture*".

Liebig's Barrel



- J. v. Liebig, 1852

We are presently in the *4th Phase* of Renewing Interest in Soil Biology

Post-Liebig
Soil CO2 Atmosphere

Wollny DE (1886),
Sewerin DE (1904))
Stoklasa CK (1905)

Pre-War
CO2 Nutrition, Microbial Fertility

Lundegårdh SE (1924)

Waksman NJ (1923)
Gainey KS (1919)
Potter IA (1916)
Russell UK (1915)

Post War pre-current
Soil Biology-Environment

Koepf* DE (1953)
Isermeyer DE (1950)
Golovko* RU 1965

Birch KE (1958)
Hilger FR (1963)
Jäggi CH (1976)

Pettersson* SE (1970)
Rusch* CH (1968)
Dlouhy SE 1980

TODAY?

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* Graduate level teachers Brinton encountered in his studies

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Liebig's legacy is a narrow-focus on fertilizers, as already warned:

"The direct action of fertilizers on increasing plant growth is the only one that attention is being paid to in agriculture."

Henrik Lundegårdh, Sweden

April 5 1926 in: *Soil. Sci. Vol xxiii*

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Therefore soil health testing MUST build a bridge from NPK to biology

- Woods End Labs initiated first comprehensive soil test in 1984 combining soil biology with physical traits AND chemistry
- Updated in 2005 in CRADA project with USDA ARS to implement cost-effective measures capable of being implemented in modern soil labs
- Goal is to “not leave farmers out” in access to soil biology on the largest scale possible

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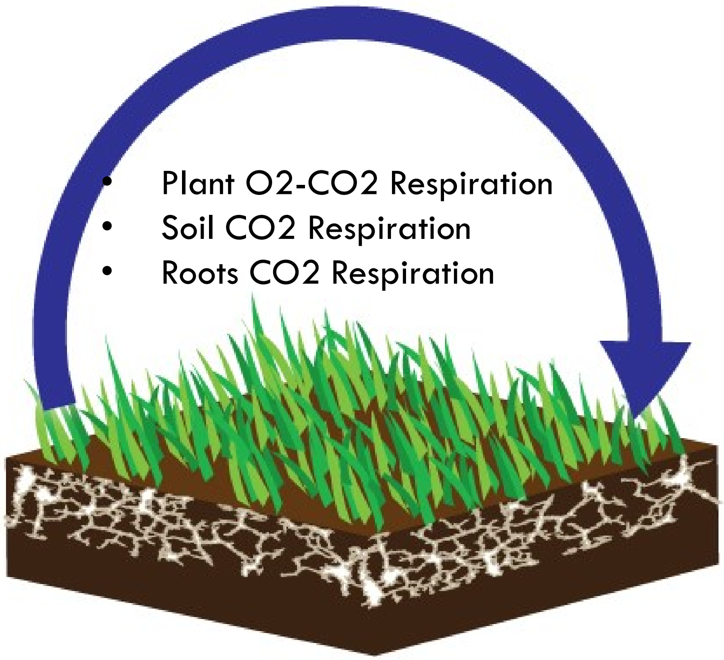
Lundegårdh’s Model: The Whole Soil

(Plant Assimilatory CO2 Demand) – (Soil CO2 + Root CO2 Respiratory Supply) = Q_{CO2}

CO2 CYCLES from soil to plant



- The Swedes brought major attention to the role of soil biology in furnishing plants with assimilatory CO2
- Brinton later studied in Sweden under Pettersson & Dlouhy (1977-79) where this theme continued in whole-system soil biology studies

Consider Crop CO_2 Requirements

(calculated for 60 day assimilatory period)

Wheat* (~ 5 Mg DM/ha) = **124 kg CO2 demand <u>per day</u>**

Maize§ (15 Mg DM) = **461 kg CO2 / day**

WHERE DOES ALL THE CO2 COME FROM?

- Lundegårdh studied wheat, oats and beet carbon assimilation
- § calculated by Brinton (2014)

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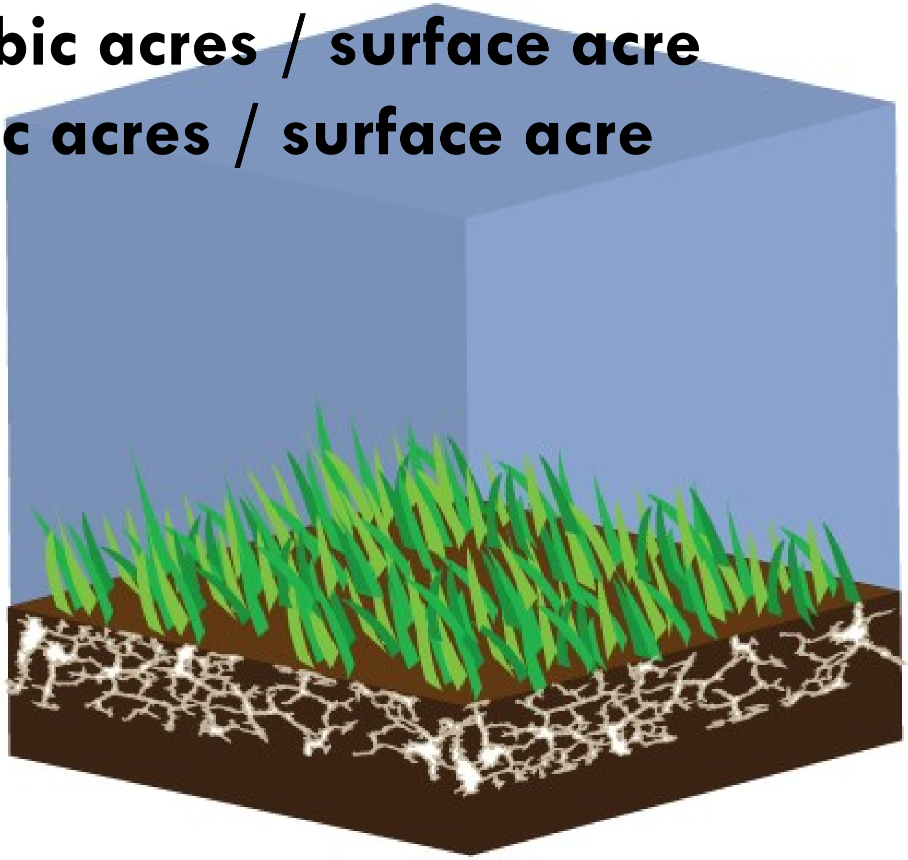
Without soil respiration, a huge mass of air must supply crop CO_2 needs.

Wheat – 10 cubic acres / surface acre
Corn – 38 cubic acres / surface acre



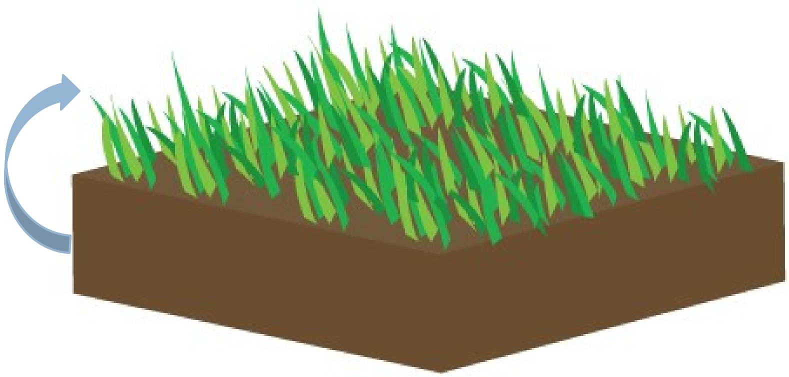
EXAMPLE:
1,000 acres of wheat requires 10,000 cubic acres of air to supply sufficient CO2

Lundegårdh's "Rich Soil/Poor Soil" Model:

A biologically-poor soil does not provide adequate CO2 but a humus rich and biologically active soil can

Low-Fertile Soil:
CO_2 yield **30 kg/ha/day**

Humus Rich Soil:
CO_2 Yield **125 kg/ha/day**



Plants must get most their CO2 from <u>air</u>

Plants obtain all their CO2 from <u>soil</u>

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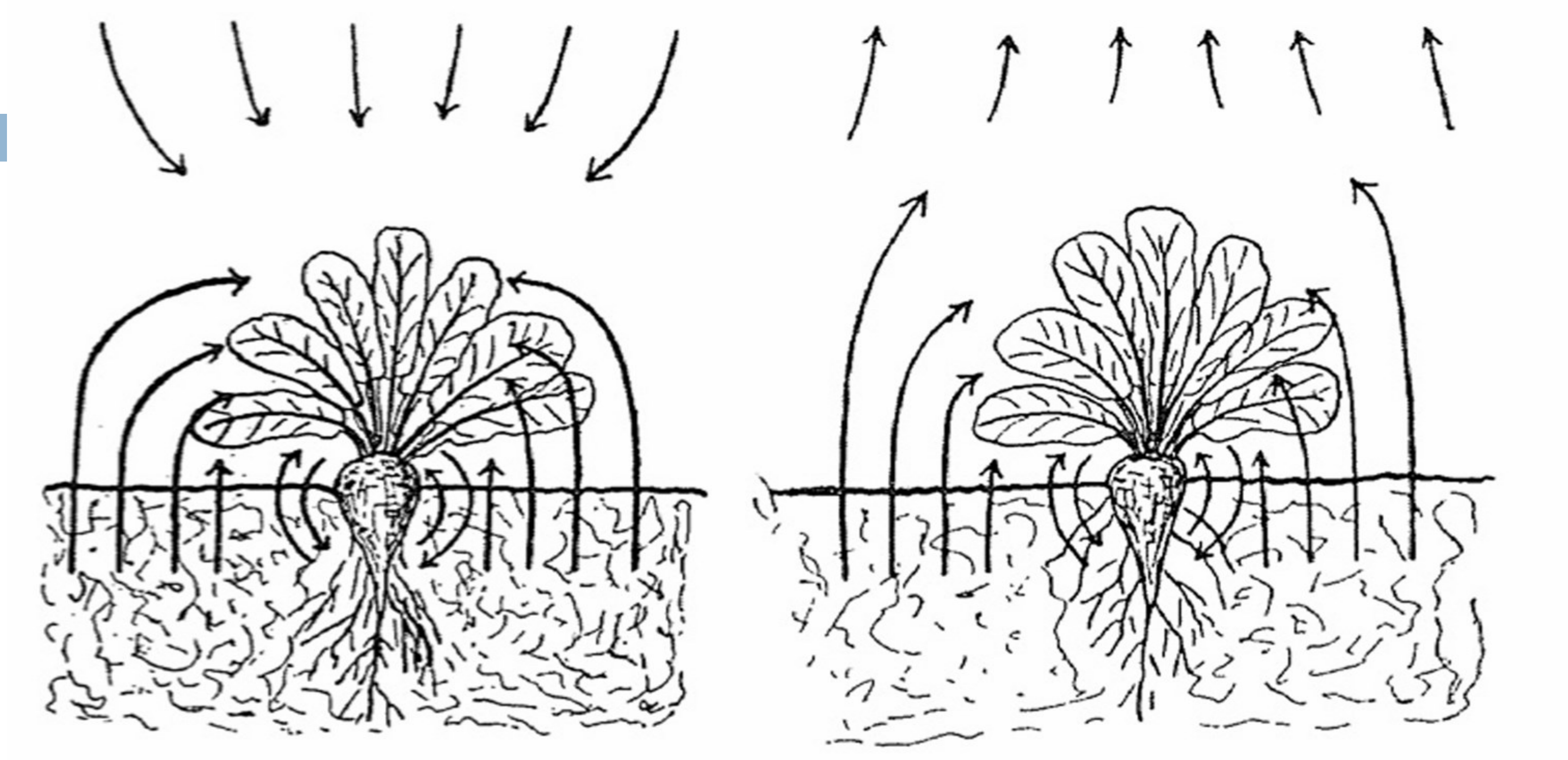
CO2 Diffusion Gradient: Two Cases



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Beet growth sketches by Lundegårdh 1926; Reproduced by Waksman (Rutgers, 1936)

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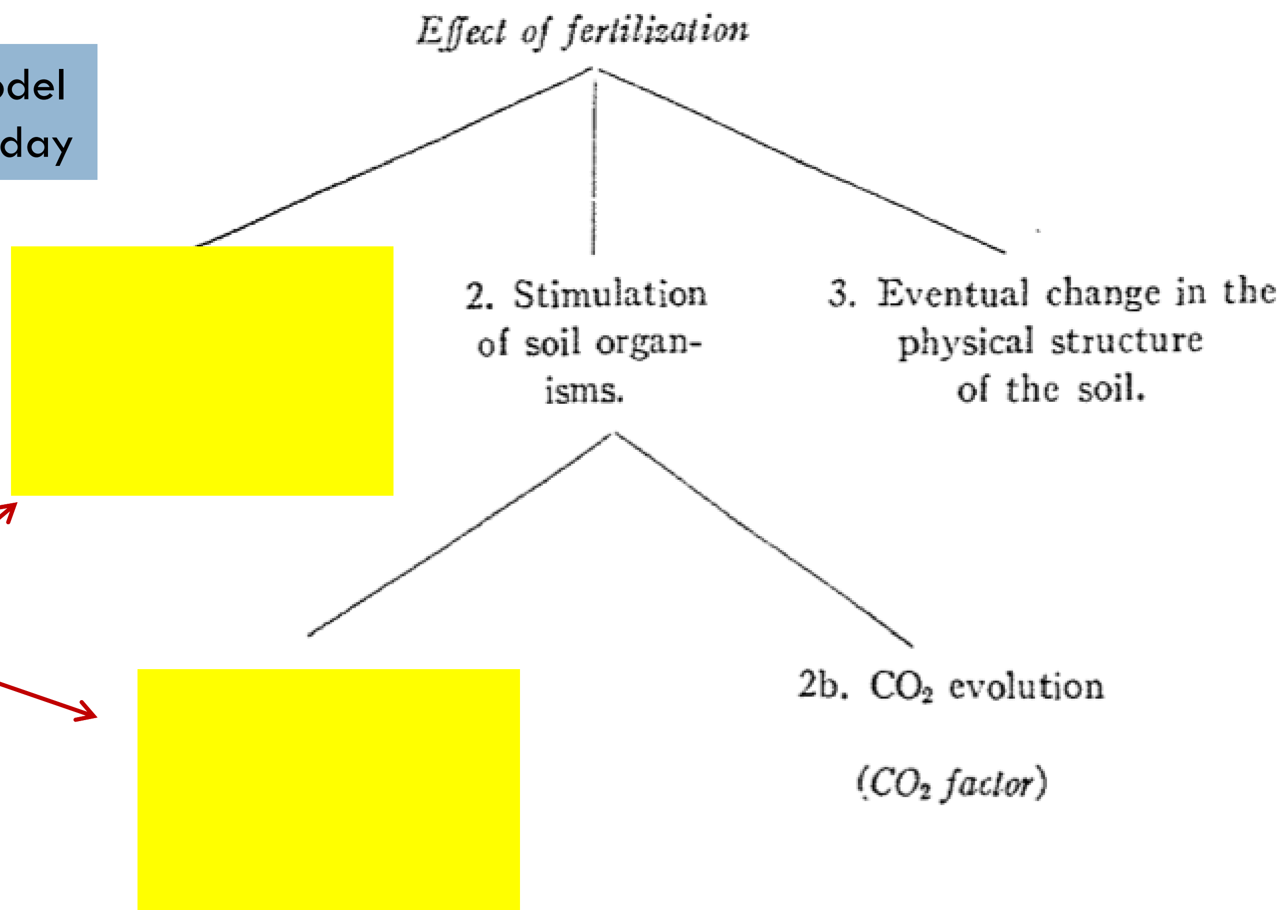
The Original Swedish Map of Soil Nutrient & Health (from 1926)

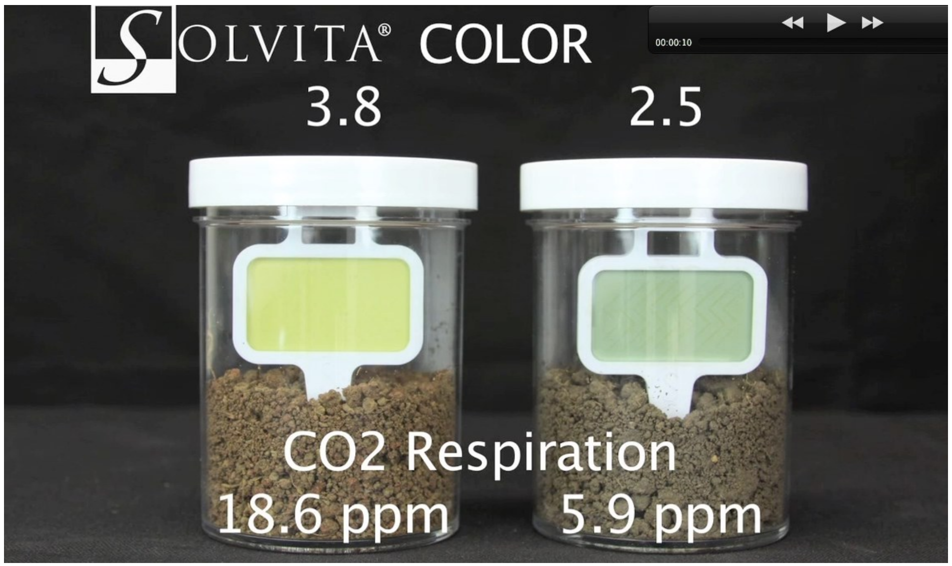
This early model still correct today



Most current attention is here

After: Lundegårdh

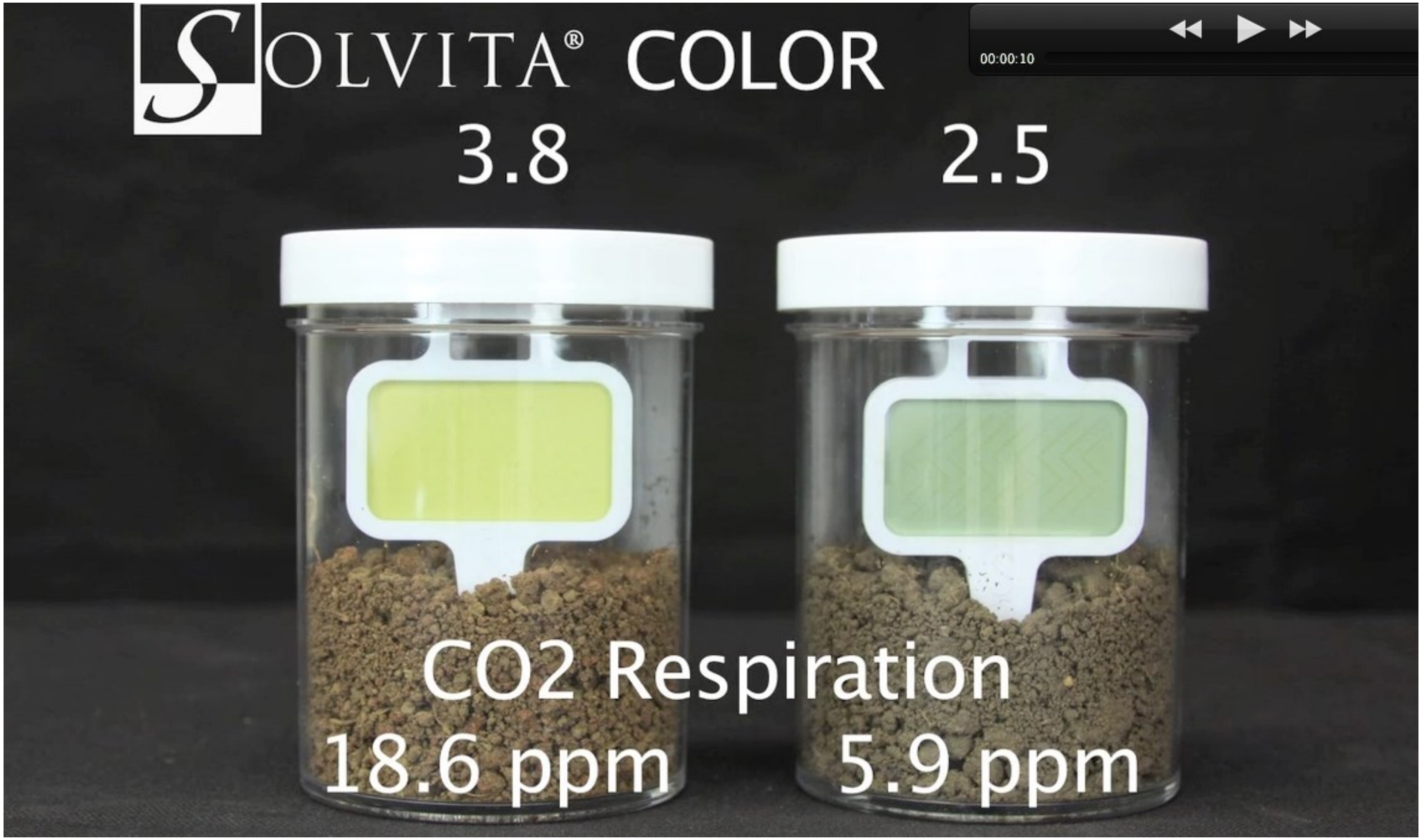
Seeing it with Solvita; a soil life test



Basal Respiration Mode shown;
Labs use CO2-Burst Mode based on Haney and Franzluebbers

- Solvita developed by Woods End to make CO_2 visual in manner that could also be quantified
- No fussy chemistry and can be used in lab and field. Listed in ALP and NAPT
- 100,000 farm soils tested worldwide 2010-2013

Soil (left) provides 60 kg/ha/day CO_2 but poorer soil (right) yields only 19 kg/ha



Original time lapse: https://www.youtube.com/watch?v=XABmvKs0070

Soil Health Tool Test

Historical Sketch

Woods End Labs Soil Testing and SHT

1) 1975 “Soil Audit” with humus test
2) 1984 N-mineralization added
3) 1989 implemented aggregate stability procedure and 7-day CO2-Respiration
4) 1996 Solvita® Basal-respiration developed
5) 2005-2010 Standardized CO2-Burst test AND adopted new “green chemistry” (Haney extract -H3A)
6) 2014 Four Commercial soil labs offer SHT*

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See: www.solvita.com/soil/map

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Soil Nutrient & Health Test

OVERVIEW

Integrates all tests

-A: *Nutrients and org. C N*

-B: *Calculated availability factors and balances*

-C: *Biological Tests and Overall Scoring*

-D: *Recommendations*

Designed for modern soil labs

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Innovative Soil Testing since 1975

290 Belgrade Road
P.O. Box 297
Mount Vernon, ME 04352
207 293 2457
for more information:
lab@woodsend.org

SOIL HEALTH TOOL RESULTS

Performed with USDA-ARS ***H3A Extraction Method***

For:

John Doe
122 Maine Street

Anytown, PA 18801

Lab ID: **5612.0** **Acct No:** **1000**
Sample: **Soil: Plot_E-L01**
Sample Received: 5/3/2014
Report Date: 5/6/2014
Crop Intended: Corn-150
QAQC:

A

	Tested Factors		UNITS	Level Found	Rating
*	Nitrate-N	NO_3-N	lb/a §	47.4	M
*	Ammonium-N	NH_4-N	lb/a	12.0	M
*	WEOC		C-ppm	209	ML
*	WEON		N-ppm	20.3	L
	SLAN *Amino-N*		N-ppm	128	ML
*	Phosphate (P⁻)	P	lb/a	16	ML
*	Potassium	K+	lb/a	156	MH
*	Calcium	Ca++	lb/a	672	VL
*	Iron	Fe++	ppm	104	M
*	Aluminum	Al 3+	ppm	234	M

B

Availability Factors		USDA-ARS (Min)	+ Climate	
Nitrogen (M-min+Avail)	lb/a	101	162	H
Phosphorus P_2O_5	lb/a	-	37	ML
Potassium K_2O	lb/a	-	187	MH

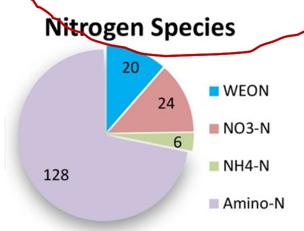
§ lb/a ÷ 2 = ppm

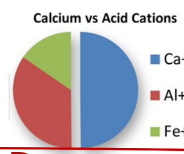
	Indicator Factors			
	P-Saturation	P/(Al + Fe)	2.4	L
*	Fe+Al (acidity indicator)	mg / kg	338	L
*	Calcium Saturation	Ca/(Fe+Al)	1.0	M

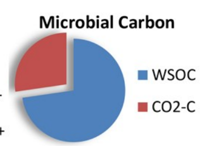
Optional Tests (not part of Soil Health Nutrient Tool)		
Soil Organic Matter	LOI %	no test
pH in Water	units	no test
Magnesium	lb/a	no test
Basal CO_2-C	ppm	no test
Est. CEC**	cmol/kg	no test

C

	Test Interpretations		*Rating*
*	Soil Health Score	11.7	M
*	Organic C:N Ratio	10.3	M
*	Solvita CO_2-Burst ppm	78.4	M
*	Microbially Active Carbon- "MAC"	38%	MH
	Micro Aggregate Stability	38%	M







D

Nutrient Calculations, Value as $/acre available				
$N + P_2O_5 + K_2O$ / acre	$ 183.86			
* ***Nutrient Requirements***	Nitrogen	Phosphate	Potash	Lime
Corn-150	49	38	none	1716
(assumed total nutrient requirement)	150	75	75	

USDA Cover Crop Recommendations
>Based on Soil Health Score of: **11.7**
Mix Recommended: 40% Legume 60% Grass

USDA Climate Zone Used for this report: 6a Note lb/acre = ppm x 2 at 6" depth

* **Soil Health Test Traits** ***Ratings: VL= V. Low L=Low, M= Moderate MH= Medium High H= High VH= Very High***

Methods: *Soil Test Procedures for the NE USA * Bulletin #493, Univ of Delaware; Soil Health Tool, USDA-ARS Temple TX; VT Aluminum Index*

All nutrients in Soil Health Tool Extract (H3A), optional SOM by LOI @360°C; **Est. CEC = Al+Ca+Mg+K

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Soil Biology Conclusion

1. Early work shows that plants may suffer temporary CO2 deficiencies at peak growth.
2. The same early work identified the *proper role of healthy soil* as furnishing CO2 for assimilation!
3. Mentioned early-on then overlooked is that soil CO2 as dissolved carbonic acid (1-3% CO2 in soil atmosphere!) could act as universal extractant of minerals for plant use.

- Modern approaches tend to overlook these traits and presently there is concern about over-parameterizing soil health into an array of separate procedures.

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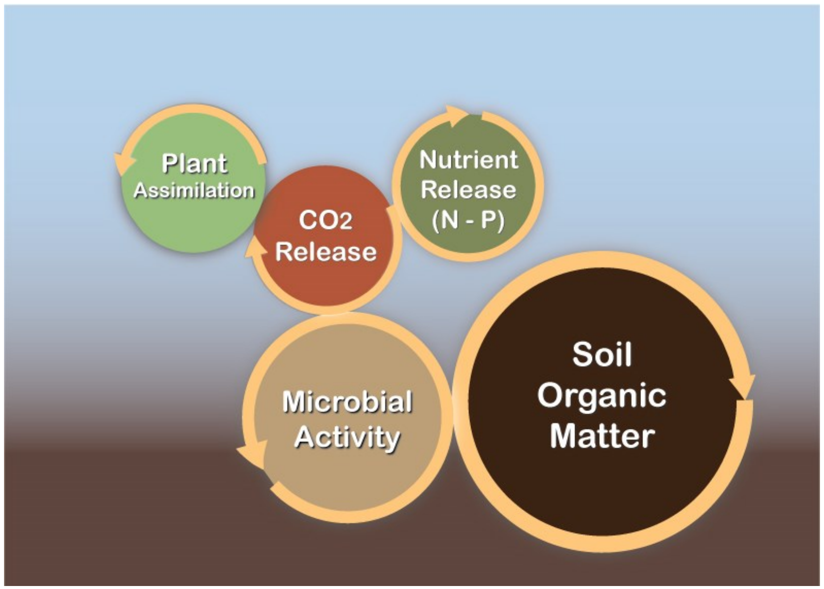
Soil Test Chemistry: Lessons Learned

- Soil lab integration *is crucial* worldwide; 50% of soil labs still take <u>no account</u> of various N sources.
- Woods End Labs and Haney-ARS partner labs taking lead in outreach to soil lab/ farming sectors
- Excessive fertilization is common- but why?
  - A) test methods & nutrient models used by soil labs?
  - B) industry (fertilizer) salesmanship?
  - C) ROI realities (crop value vs/ fertilizer cost)?
- Farmer response very positive for Soil Health Tool.

Contacts …

Thank you to Farm Foundation



- Solvita available from SOLVITA.COM
- Soil Health Tool Test available from: Woods End Labs ME (WOODSEND.ORG) *and other labs*

(lab@woodsend.org)