Soil Health Course; What is soil health?

By Ian Mot
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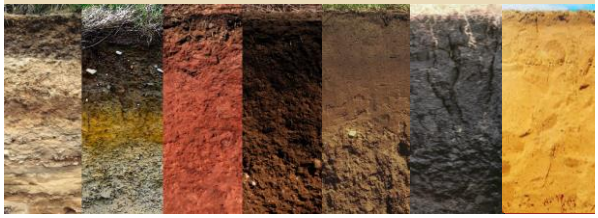

I'm here to

- Empower with information
- Tell you that you have the power to change your situation
- Tell you why it's important
- To give you a place to try your hand at it

Note: Pointing to the ideal

Acknowledgements

2

Lets consider the character of Soil & Man:

Gen 2:7 "So the Lord God formed the man from the **dust of the ground**, **breathed life** into his lungs, and the man became I living being"

How did Adam inherit the character of God? From the breath or dust?

The dust had been made in the image and character of God

3

"**God made man** perfectly holy and happy; and the **fair earth**, as it came from the creator's hand, bore no blight of decay or **shadow of the curse**.

It is transgression of Gods law – the law of love – that has brought woe and death. Yet even amid the suffering that results from sin, God's love is revealed.

It is written - God cursed the ground **for Man's sake** (Gen 3:17)

The thorn and the thistle – the difficulties and trials that make this life one of toil and care – were appointed for his good as part of the training needful in God's plan for his uplifting from the ruin and degradation that sin has wrought"

Chapter 1, Page 1 "Steps to Christ"

4

Wars are fought over land, and you're the King

Gen 1:6 "And God said, Let us make man in our image, after our likeness: and let them **have dominion** over the fish of the sea, and over the cattle, over all the earth, and over every creeping thing that creepeth upon the earth"

Then man fell and lost there dominion

Mathew 4:8-9 "…the devil taken him up into an exceedingly high mountain, and showeth him all the kingdoms of the world, and the glory of them; said to him, "I will give all this to you, if you will bow down and worship me"

5

Wars are fought over land, and you're the King

Mathew 28: 18

"And Jesus came and spake unto them, saying, **All power is given unto me in heaven and in earth**"

6

Wars are fought over land, and you're the King
Psalms 8:4-6

"What is man, that thou art mindful of him? and the son of man, that thou visitest him?

For thou hast made him a little lower than the angels, and hast crowned him with glory and honour.

Thou madest him to have **dominion** over the works of thy hands; thou hast put all things under his feet:"

7

What did Agriculture look like?

Before the fall	After the fall
Healthy plants	Plant diseases and Pests
Healthy animals and humans	Disease/pain (Birth labour)
No tillage	Tillage work introduced
Water supplied	There should not be a stress for water
The yield of cannan	Lost prosperity
No weeds problems	Thorns and thistles

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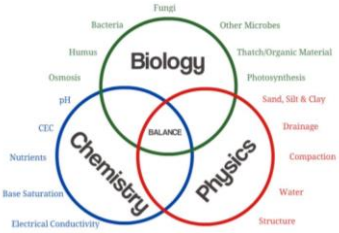
What is soil Health?



https://bowls-central.co.uk/sweet-spot/

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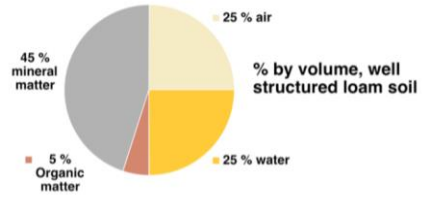
What is soil Health?



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Soil Chemistry

- Essential Pant Nutrients
- Principles of Plant Nutrition
- Nutrients Roles
- Nutrient pools
- Colloids
- CEC
- Soil colloid vs Soil solution Theory
- Nutrient cycles
- How to measure Soil Health
- What is a soil test
- Examples of how soil chemistry falls apart

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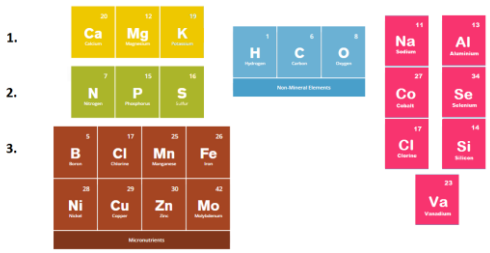
Essential Plant Nutrients + Beneficials



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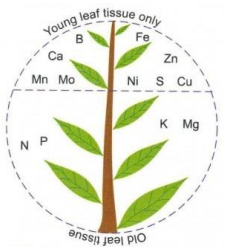
Principles of plant nutrition

- All nutrients are required in specific amounts as building blocks
- Nutrients are needed on time – otherwise stunted
- Nutrient deficiency = disease, low quality, low yield
- An excess of a nutrient = deficiency of another nutrient
- Nutrition self distributes = Mobile/Immobile
- Two types of nutrition
  - Minerals – Ca, Mg, K, P etc
  - Energy – Proteins (20 Amino acids) & Carbohydrates
- Hidden Hunger = Unable to see the deficiency
- Nutrient demand dependant on growth rate

Principles of plant nutrition

Mobile – N, P, K, Mg, B, Cl, Mo

Immobile – Ca, S, B, Cu, Fe, Mn



http://msue.anr.msu.edu/news/identifying_nutrient_deficiency_symptoms_in_field_crops

Nutrients Roles

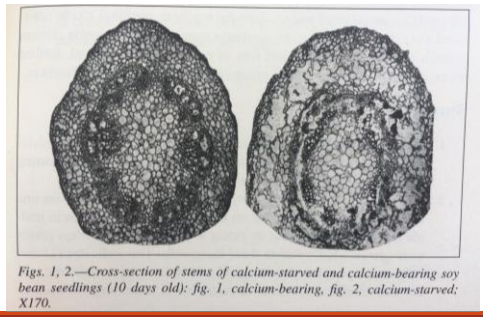
Calcium – Structural building block to cell walls
Boron – Calcium effectiveness, flowering

Potassium – regulates nutrients and cell functions
Zinc – Enzymes & water use efficiency
Copper – Enzymes & Disease resistance
Phosphorus – ATP production, cell division

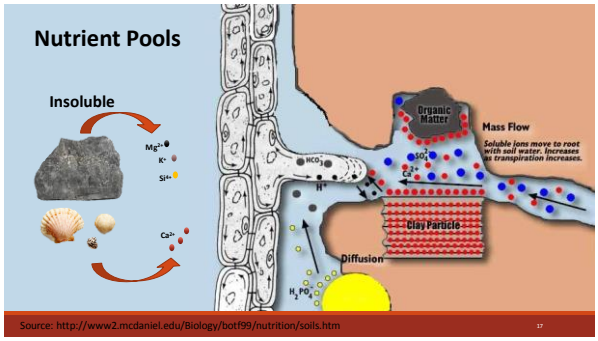
Moly – Nitrogen Fixation & usage

Magnesium – makes green Chlorophyll critical to Photosynthesis
Iron – Photosynthesis
Manganese – Photosynthesis

Nitrogen/sulfur – Form amino acids & proteins

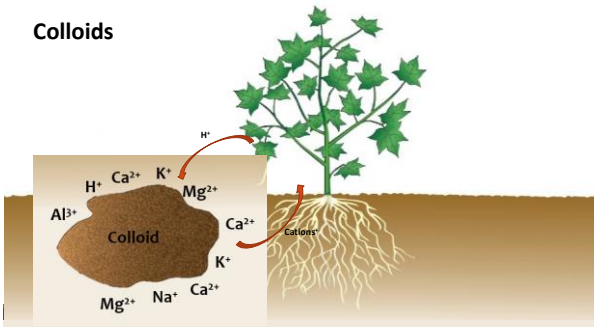


Figs. 1, 2.—Cross-section of stems of calcium-starved and calcium-bearing soy bean seedlings (10 days old): fig. 1, calcium-bearing, fig. 2, calcium-starved; X170.



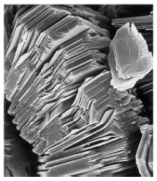
Source: http://www2.mcdaniel.edu/Biology/botf99/nutrition/soils.htm

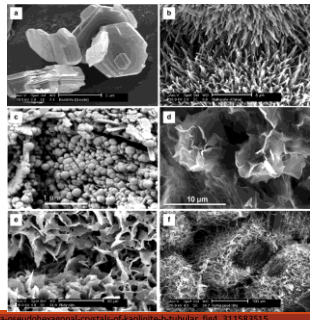
Colloids



Colloids

- Clay crystal or humus





https://www.researchgate.net/figure/SEM-images-of-clay-minerals-a-pseudohexagonal-crystals-of-kaolinite-b-tubular_fig4_311583515

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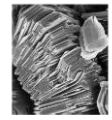
Colloids and soil structure

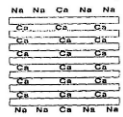
- Each ion has a different size
  Ca, Mg, K, Na

3 factors affect the width between colloids

- Cation type
- Mineral type
- Concentration level

Kaolinite crystals





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What is Soil Cation Exchanged Capacity (CEC)

Kaolinite clay with - 15 cmol/kg
Humus at – 400 cmol/kg

My soil = 40% clay, 3% organic carbon

= (15 x 0.4) + (400 x 0.03)
= 6 + 12
= 18 cmol/kg

Soil Constituent	CEC / (cmol kg^{-1})
Montmorilonite	80-120
Vermiculite	120-150
Kaolinite	3-15
Sesquioxides	2-4
Soil organic matter (SOM)	100-300
Humic fraction (2/3 of the SOM)	400-800

https://www.researchgate.net/figure/Typical-values-for-the-CEC-of-clay-minerals-and-organic-colloids-found-in-soils-of_tbl2_221899783

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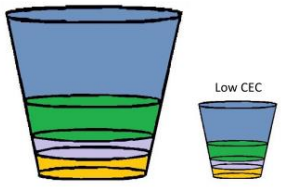
What is Soil Cation Exchanged Capacity (CEC)



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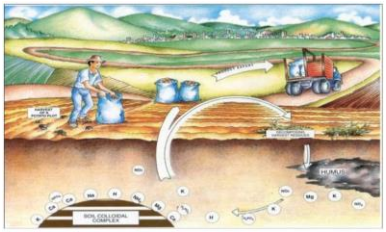
Nutrient Cycles



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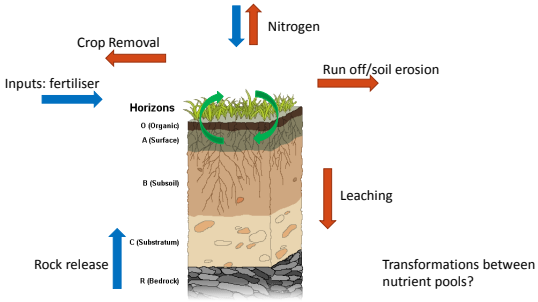

Soil Profile

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Nutrient removal

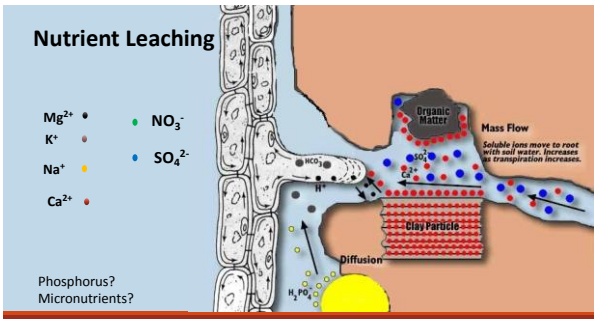
Table 3. Equivalent weight of lime (as $CaCO_3$) required to replace the alkali removed per hectare of farm produce in north-eastern Victoria

	Yield[A] (t/ha)	$CaCO_3$ (kg/ha.year)		Yield[A]	$CaCO_3$ (kg/ha.year)
	Plant production			*Animal production* [B]	
Lucerne hay	3–7	540–1260	Dung	210 g/day.sheep[C]	50
Mixed grass hay	3–7	270–630	Urine	1600 mL/day.sheep[C]	18
Lupin	0.6–1.3[A]	12–26	Lambs	10 lambs/ha[D]	6.0
Barley	1.2–2.3[A]	10–18	Wool	6 kg/sheep	0.8
Triticale	1.0–2.8[A]	7–20			
Wheat	1.2–2.1[A]	11–19			

[A] Australian Bureau of Statistics (1990). [B] Assumes a stocking rate of 10 sheep/ha. [C] Vercoe (1962). [D] Ferguson (1979).

Slattery et al 1991 - Ash alkalinity of animal and plant products

Nutrient Leaching



Phosphorus?
Micronutrients?

Source: http://www2.mcdaniel.edu/Biology/botf99/nutrition/soils.htm

Three types of biological N_2 fixation

System of N_2 fixation (and microbes involved) ($N_2 \rightarrow NH_3$)	SYMBIOSIS (e.g. *Rhizobium*)	ASSOCIATION (e.g. *Azospirillum*)	FREE-LIVING (e.g. *Rhodospiorillum*)	
Energy source (Organic C)	Sucrose from the host plant	Root exudates from the host plant	Heterotroph (plant residues)	Autotroph (photo-synthesis)
Estimates of fixation rate (kg N/ha/y)	50-400	10-200	1-2	10-80

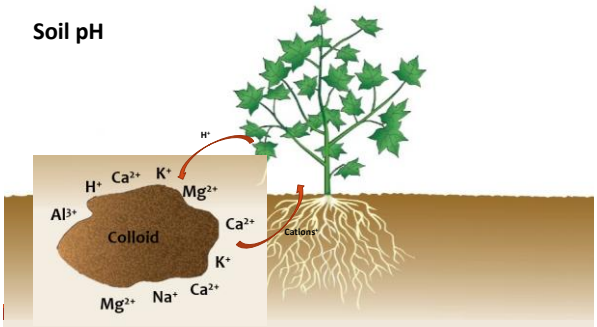
Celery example

80% nitrogen loss

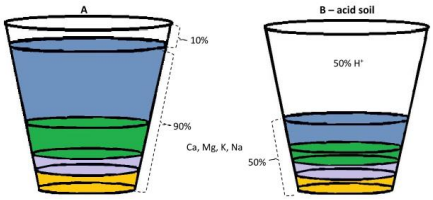
Nitrogen loss from plant soil systems (% of applied)

Crop	Country	Loss
Maize	Indonesia	50-58
Rice	Australia	46
	China	63-72
	India	54-78
	Philippines	45-56
	Thailand	14-85
Sugar cane	Australia	47-61

Soil pH



Soil colloid vs Soil solution Theory



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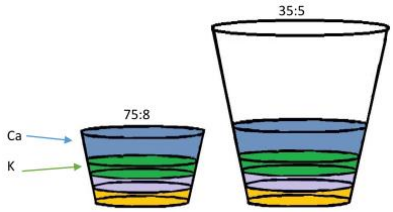
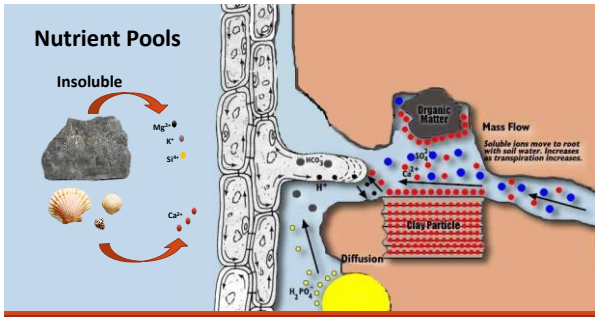




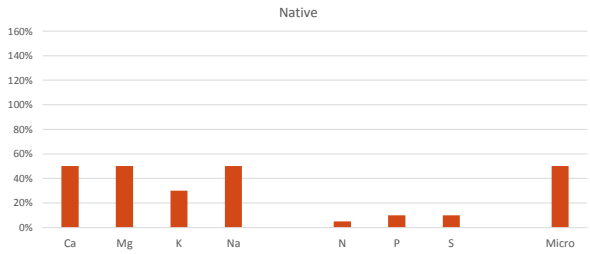
Source: http://www2.mcdaniel.edu/Biology/botf99/nutrition/soils.htm

Soil solution lime reaction

$$Ca(OH)_2 + H^+ \longrightarrow Ca^{2+} + H_2O$$

Hot House Soil Salinity Example

Compost/manure Example



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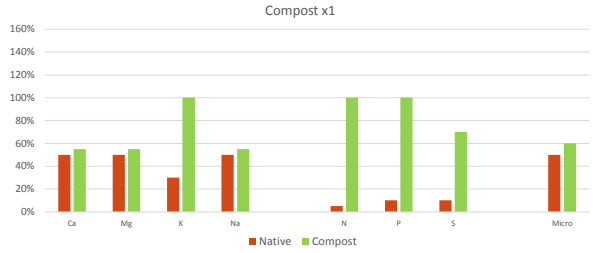

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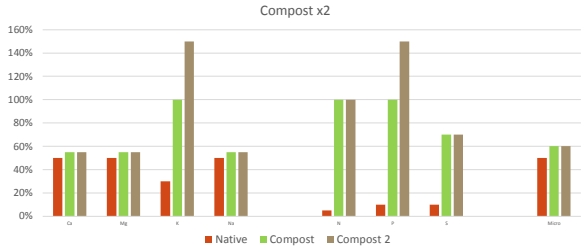
Compost/manure Example



http://counties.agrilife.org/valverde/files/2014/11/Phosphorus-Too-Much-Plants-May-Suffer.pdf 38

Chemistry Resources

- *Hands on Agronomy* - Neal Kinsey
- *The Ideal Soil* - Michael Astera
- *Understanding & Achieving Optimum Soil Balance* – Edward Mikhail

- *Mineral Nutrition of crops* - Rengel
- *Management of Diseases with Macro- and Micro Nutrients* – W. Engelhard
- *Mineral Nutrition of Higher Plants* – Petra Marschner
- *Mineral Nutrition and Plant Disease* – Datnoff, Elmer, Huber

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Soil Health Course; How can we measure Soil Health?

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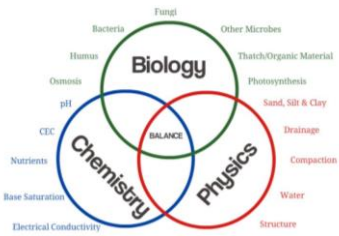
What's soil Health?



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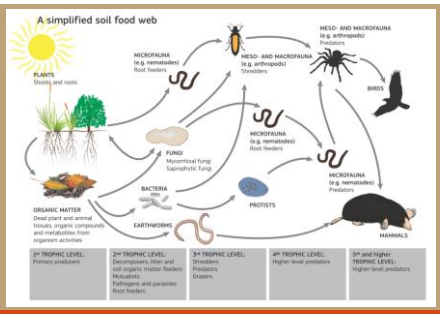
Soil Biology

Population Density

What do living things need
- Shelter
- Water
- Food
- Waste management
- Hierarchy
- Separation
- Job

Nowhere in nature are species so densely packed as in soil communities (Hågvar, 1998).

A single gram of soil may contain billions of individuals and several thousand species of bacteria



Global Soil Biodiversity Atlas

Bacteria

Functions
- Decompose material
- Fix Nitrogen
- Feed

Photosynthetic bacteria – able to break down organic matter and pesticide and petrochemical residues

Yeasts - synthesise plant growth substances

Streptomyces spp produce antibiotic compounds suppressing soil pathogens And produce plant hormones

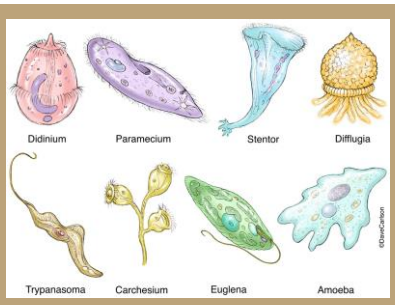
Fungi

One individual up to 15 hectare in size

Functions
- Produces humus – Humification
- Decompose organic material
- Break down rock
- Soil structure
- Supply water to plants (mycorrhizal fungi)
- Feed for other organisms

Protozoa

Functions
- Eat Bacteria
- Swim around



https://www.carlsonstockart.com/photo/protozoa-diversity-protists-unicellular-illustration/

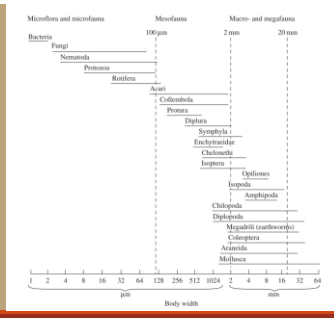
Nematodes

Functions
- Bacterivores
- Fungivores
- Herbivores
- Omnivores
- Predators

Arthropods

Functions

Pore sizes



"The biology of soil, a community and ecosystem approach" – Richard Bardgett 2005

Bioturbation:

https://www.youtube.com/watch?v=Mxp1nnrUG0Q

Soil Biology Resources

- Global Soil Biodiversity Atlas
- Soil Biology Primer – Elaine Ingham
- Teaming with Microbes – Jeff Lowenfels & Wayne Lewis
- Mycelium Running – Paul Stamets

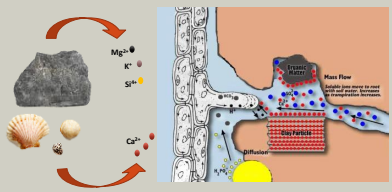
Measuring Soil Health - Tools:

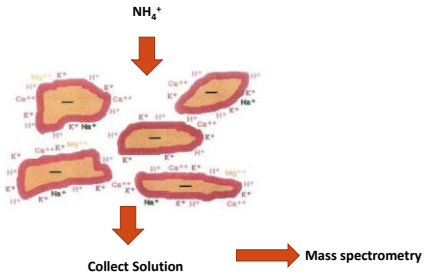
Physics
- Texture analysis jar (sand, silt, clay)
- Bulk density
- Penetrometers
- Infiltrometer (Infiltration)
- Aggregate Stability test

Chemistry
- Soil Lab
- Home kits
- pH kit/meter
- EC Meter

Biology
- Microscope
- Soil labs
- Indicator species

What does a soil test actually measure?





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Why do a soil test

- Learning from your unique soil situation
- Measuring tools are for people who are learning
- Free soil test from 100m2 because of fertiliser savings
- Smaller areas worth the value if quality matters
- Guaranteed results

- Lab Choice

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Soil Health Course;

How too keep soil health?

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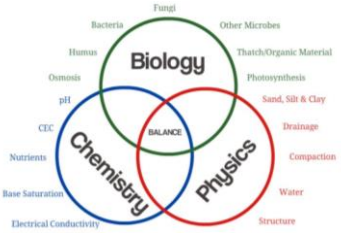
What's soil Health?



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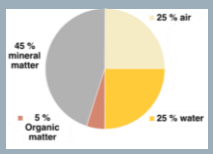
I ask these questions

Is the system creating a physics problem?
Is the system have a chemistry problem?
Does the system have a biology problem?

Does the system build or degrade carbon?



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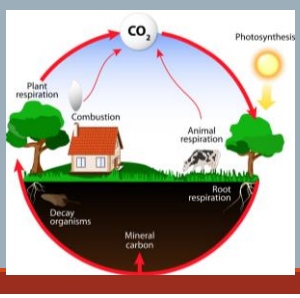
Carbon Cycle of Life



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Types of soil Carbon?

Crop residue Particulate Humus Resistant carbon Biology

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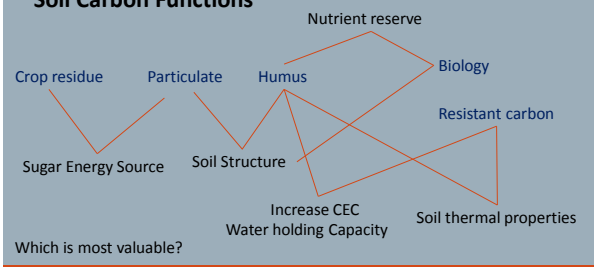
Soil Carbon Functions



Which is most valuable?

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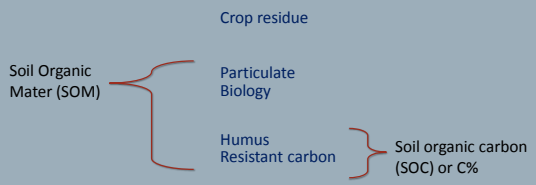
Soil Carbon on a soil tests:



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How is humus made? Humification

1. High photosynthesis = large sugars exudates
2. Bacterial thrive on the sugar and mine soil for nutrients
3. Bacteria die, get eaten by predators releasing "superior nutrients" for plants
4. Superior plant growth = plant lipid formation
5. Followed in fungal digestion because bacteria does not digest lipids

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Alternative carbon sources:

Import
- Compost
- Manure
- Biochar
- Straw and wood chips

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