HUMUSING LINK

Presented by Ken Bailey

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Soil Organic Carbon and Atmospheric N₂ Fixation

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"Observe nature, read books, if the two don't agree, throw away the books."

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Professor William Albrecht



Luebke's Crumb Structured Soil

Luebkes C & N Sequestration

Start Point

- 2.6 % SOM
- In top 100mm
- 16.9 tons of C
- Total reading N 1126 kg / ha

End Point 5 years later

- 16.8% SOM
- Top 900 mm deep
- = 960 tons of C
- N sequestrered 64,000 kg/ha or 12,800 kg / year
- Carbon value @ \$30.00
 /ACCU \$66,000









How to Make Aggregates?

 Right biology to make a carbon polymer which are called:

"extra cellular polymeric substances".

- Needs to be recalcitrant (resistant to being broken down further by enzymes).
 Last 50-100 years.
- Carbon needs to be chemically active.(charged state)
- Clay makes it easy.



Biological Requirements

- "Free Living Nitrogen Fixers" (FLNF) that convert N₂ into NH₃ or N containing metabolites,
- "Auto Inducers" are compounds that lead to Quorum Sensing
- Quorum sensing; Scientific definition is; "Density dependent coordinated behavior that regulates gene expression."
- The nitrogenase enzyme. But you need a low oxygen environment.



Extra Cellular Polymeric Substances



Fig. 7.4. ESEM images of *Pseudomonas aeruginosa* PG201 cultivated in moist sand with aqueous mineral media and glucose as the carbon source, where (a) two sand grains are bridged by a micro-colony embedded in EPS and (b) copious EPS is observed to span mineral grains. Specimen preparation, instrument and imaging conditions are as per those in Fig. 7.1, except that part (b) was stained with ruthenium red as per Priester *et al.* (2007). Note the connection point between EPS-embedded cells and the upper grain, where a radius of curvature is observed in the biological matrix.







Clay Humus Crumb





Necromass

"At the end of its life, microbial biomass contributes to the microbial molecular imprint of SOM as necromass with specific properties." REVIEW article Front. Environ. Sci., 14 December 2021 Sec. Soil Processes











Atmospheric Nitrogen Fixation

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- Nitrogenase Enzyme contains Molybdenum.
- Metallo enzyme need Iron as cofactor to donate electrons
- $(N+N) + 8^{E} + 8H + 16 ATP =$ NH³ + NH³ + 2H₂O + 16ADP + 16 P₁

- C:N Ratio 12:1 is the objective.
- Therefore 1% > C in top 300 mm = 40 tons = 3,300 kg of N



Photosynthesis

- Glucose ($C_6H_{12}O_6$)
- Rate can vary by as much as 3-4 times, dependent on plant nutritional status.
- Nutritional deficiencies create bottlenecks.
- Healthy soils come healthy plants.
- Photosynthesis is the engine that drives soil regeneration.
- Root exudates as a % of photosynthates can from 5% to 95%.



The Jena Biodiversity Experiment

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The Jena Experiment





Jena Biodiversity Experiment

1, 2, 4, 8 or 16 plant species 0, 100 or 200 kg N/ha/yr **Higher plant diversity produced** greater plant yield than higher applied N.



Jena Biodiversity Experiment





Multi Species Trial



Chase Thornhill, Mendocino Wine Company, Ukiah, CA (August 2021)



Multi Species





Magomadine Wheat 2021











Western River Loam Trial





Soil Health Requirements

Soil health requires a minimum of Four Functional Groups of microbes.

i.e. minimum four plant families





Carbon Sequestration

- Fungal Energy Pathway
- Bacterial Energy Pathway
- Pulsing plants is critical management strategy.
- Especially at flowering.
- Hay, silage, rolling or crimping, crash grazing or pulse grazing.



DIVERSE systems are self-organising.

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The <u>MICROBES</u> know what to do!!!



Definition Soil Fertility

 The capacity of a soil to sequester and convert atmospheric N into plant available N such that it would completely negate all responses to synthetic N.

 This is the basis for a high production Regenerative / Organic Agricultural system.



Soil Carbon Project

- Top metre of soil contains 13,000 tons of soil
- At 0.1% increase / year = 13 tons OC
- At 10 years = 130 tons

- An ACCU is one of CO₂^E
- One ton of soil carbon =3.67 CO2^E
- One ACCU is worth \$30.00
- Therefore 130 x 3.67 x 30 = \$14,313/ ha / 10 yrs of project + or – costs x 1000 ha = a telephone number...







TALE IS

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