What is Soil Health?

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What is a Healthy Soil?

Biology

Chemistry

Physics

What is a Healthy Soil?

Healthy Soils

Partitioning Photosynthates

• Photosynthates are excreted as root exudates:
  - Annuals/cereals: 20-30%
  - Perennials/pastures: 30-50%

• Understanding the function and fate of these root exudates is currently a hot spot of scientific endeavor.

A cocktail of root exudates...

<table>
<thead>
<tr>
<th>Class of compounds</th>
<th>Sugar compound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbohydrates</td>
<td>Glucose, fructose, sucrose, lactose, maltose, mannose,阿拉伯糖, galactose, raffinose, etc.</td>
</tr>
<tr>
<td>Amino acids</td>
<td>Glutamic acid, aspartic acid, glycine, alanine, valine, leucine, isoleucine, cysteine, etc.</td>
</tr>
<tr>
<td>Steroids</td>
<td>Cholesterol, vitamin D, vitamin E, vitamin K, etc.</td>
</tr>
<tr>
<td>Lipids</td>
<td>Fatty acids, phospholipids, sterols, etc.</td>
</tr>
<tr>
<td>Vitamins</td>
<td>Vitamins A, B, C, D, E, K, etc.</td>
</tr>
<tr>
<td>Minerals</td>
<td>Calcium, magnesium, potassium, sodium, iron, manganese, zinc, etc.</td>
</tr>
<tr>
<td>Trace elements</td>
<td>Copper, iodine, selenium, etc.</td>
</tr>
<tr>
<td>Essential elements</td>
<td>Nitrogen, phosphorus, sulfur, etc.</td>
</tr>
</tbody>
</table>

Image: Glyn Bengough


What drives a healthy soil?

Chemistry

Physics

Biology

SOM

The Soil Food Web

Bacteria, Fungi and Carbon

A body of evidence suggests fungi are more important than bacteria for soil carbon sequestration:

1. Fungi store more C in their biomass than bacteria.
2. Fungal bodies and metabolites/by-products are more chemically complex and resistant to degradation.
3. Fungal hyphae promote soil aggregation which physically protects soil organic matter.

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Fungi: Bacteria and Carbon Sequestration

- Root residues:
  - Crop residues
  - Composted manure
  - Cover crops/cover crops

- Fungal biomass:
  - Large/complex C chains
  - Greater C sequestration

- Bacterial biomass:
  - Small/simple C chains
  - CO2

- By-products:
  - Respiration

Bacterial and fungal by-products glue soil particles together.

Shoots

Roots

Exudates

#RootsNotShoots

A growing body of evidence highlights the contribution of root litter/residues as more important sources of C to the soil organic carbon pool when compared to shoot residues.

- Schmidt et al. (2011)
- Clemmensen et al. (2013)
- Mascioli et al. (2015)
- Jackson et al. (2017)
- Solid & Bradford (2018)
- Berhongaray et al. (2018)

Global Change Biology

Soil organic matter turnover is governed by accessibility not reaeration

#RootsNotShoots

A growing body of evidence highlights the contribution of root litter/residues as more important sources of C to the soil organic carbon pool when compared to shoot residues.
What about Root Exudates?
Roots, Exudates & Aggregates

- Roots and exudates play a critical influence on soil chemical, physical and biological interactions.
- Root litter C is more important than shoot litter C.
- Evidence is emerging that root exudates may be even more important still.
- Microbial transformation of these C inputs is key to stabilizing SOC.
- Physical protection of aggregates is also essential.
- All of this suggests that perhaps the 'living roots' soil health principle should be taking more of a front seat in our management strategies.
Increasing Plant Diversity

- Novel cash crops
- Wider rotations
- Annuals/Perennials
- Summer/Winter
- Cover crops
- Companion crops
- Intercropping
- Biodiversity Margins
- Agroforestry
- Silvopastures
Grazing exclusion was associated with:
- less belowground C allocation
- less root biomass
- less root exudation
- less microbial biomass
- lower soil organic carbon

Soil Health is function of soil biology, physics, chemistry → plant health → soil health
Tusen Takk

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