Knowing your soils: Practical soil analysis and monitoring
Soil analysis methods

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• Soil EIP Project
• Winston Churchill Fellowship 2017/18

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Standard analysis: pH, P, K, Mg
Soil Organic Matter (SOM) analysis

- **Loss on ignition** – soil carbon – total organic matter
- **Soil Protein**
  - Gives an indication of potential N supply
- **Active Carbon** (Potassium permanganate) test
  - Measures the labile carbon, the active carbon
  - Better indication of soil fertility than SOM
Soil Analysis of other Macro and Trace elements

- Nitrogen: Nitrate, ammonium, available
- Mg, Ca, S
- Fe, Mn, Zn, Al, Ca, Na, Cu, Bo, Mo, Cl
- Se, Co

For health of:
- Soil organisms
- Plants
- Animals
- Humans
Soil Health Analysis
(NRM, Cornell, Haney)

• Physical:
  o Available Water Capacity
  o Surface Hardness
  o Subsurface Hardness
  o Aggregate Stability

• Biological
  o Organic Matter
  o Soil Respiration
  o (Soil Protein)
  o (Active Carbon)

• Chemical
  o pH, P, K, Mg
  o Trace elements: Mg, Fe, Mn, and Zn (Al, Ca, Na)

• Inform overall management rather than fertiliser inputs.
• Key elements:
  – Rectifying soil structure and biological activity
  – Consideration of nutrient reserves in deciding on fertiliser inputs
  – Nutrient balancing in order to optimise nutrient availability to the plant. Optimum cation proportions:
    65 - 85% Calcium
    6 - 12% Magnesium
    2 – 5 % Potassium
Evidence for the Albrecht/BCSR analysis and management

• Oberacker: BCSR only more effective in certain crops and tillage systems

• Missouri: BCSR positive for soil biology, chemistry and structure = yield and quality

• Allerton: £6/ha increase in Gross Margin
## Plant Tissue Analysis

**SAMPLE NAME: MANITOBA REG**

**CROP: CEREAL**

<table>
<thead>
<tr>
<th>ANALYSIS</th>
<th>RESULT</th>
<th>INTERPRETATION</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (N)</td>
<td>1.44 %</td>
<td>Deficient</td>
<td>N is deficient. Possible causes: low N application, low soil available-N, low soil P.</td>
</tr>
<tr>
<td>Sulphur (S)</td>
<td>0.095 %</td>
<td>Low</td>
<td>S is deficient. Possible causes: low soil Sulphate, excess soil N on low organic matter soils, low S fertilisation, high leaching.</td>
</tr>
<tr>
<td>Phosphorus (P)</td>
<td>0.359 %</td>
<td>Normal</td>
<td>Nutrient status satisfactory.</td>
</tr>
<tr>
<td>Potassium (K)</td>
<td>1.82 %</td>
<td>High</td>
<td>K is deficient. Possible causes: low soil K, low K application excessive N applied, cold wet spots.</td>
</tr>
<tr>
<td>Calcium (Ca)</td>
<td>0.273 %</td>
<td>High</td>
<td>Nutrient status satisfactory.</td>
</tr>
<tr>
<td>Magnesium (Mg)</td>
<td>0.074 %</td>
<td>Deficient</td>
<td>Mg is deficient. Possible causes: low soil Mg, low soil pH, use of high Ca lime, naturally low Mg soil! high soil K, high available N</td>
</tr>
<tr>
<td>Manganese (Mn)</td>
<td>54.7 mg/kg</td>
<td>Normal</td>
<td>Nutrient status satisfactory.</td>
</tr>
<tr>
<td>Iron (Fe)</td>
<td>78.1 mg/kg</td>
<td>Normal</td>
<td>Nutrient status satisfactory.</td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>6.21 mg/kg</td>
<td>Normal</td>
<td>Nutrient status satisfactory.</td>
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<tr>
<td>Zinc (Zn)</td>
<td>21.7 mg/kg</td>
<td>Low</td>
<td>Zn is low. Possible causes: low soil Zn, high soil pH leaching, high soil P, low soil organic matter.</td>
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<tr>
<td>Boron (B)</td>
<td>2.44 mg/kg</td>
<td>Low</td>
<td>B is deficient. Possible causes: low soil B, high soil pH, highly leached sandy soils or low organic matter soils.</td>
</tr>
</tbody>
</table>

The points summarised above are only meant as a guide to the likely cause of a nutrient problem. It is beyond the scope of this report to consider trace element interactions, lock up etc.
Conclusion: how should I monitor soil?

- Each farmer should choose an analysis and soil management system that suits their situation.

- **Initial analysis** of a new field: comprehensive analysis, including pH, P, K, Mg, S plus organic matter and trace elements Na, Fe, Cu, Zn, and Bo. If needed Co, I and Se.

- **Ongoing Routine analysis**: as a minimum:
  - standard pH, P, K, Mg analysis all fields at least once a rotation at start of the ley/GM. Add S analysis on arable. Repeat analysis at end of ley if deficiencies.
  - Standard analysis plus active carbon/organic matter on 2+ representative fields every year.

- **Additional trace element**, N min and plant tissue analysis is very useful to help resolve problems and identify constraints to yield or crop quality.

- If you want to **fine tune**, particularly for high value cash crops and dairy consider BCSR/Albrecht, but beware of the analysis cost and input costs — it will not be cost effective in all situations.

- Potential for **plant tissue analysis**.
- Potential for **mycorrhiza analysis**.

- Dig, walk, look, smell.
How do we test for soil carbon?
Is it linked to soil organic matter?
Lots of different methods / analysis / tests / confusion
Impact of soil depth
How carbon is reported - %ge (saturation) or yield (t/ha).
Payments for farmers for carbon
Project Aims:
To understand in more detail how farmers can build soil health and business resilience and its links to soil organic matter and soil organic carbon content.
By:
• Assessing how to test for soil carbon
• Understanding the impact of testing depth
• Evaluating the link between soil organic matter and proxy measures
• Investigating the impact of soil carbon on whole farm carbon footprint
• Assessing the impact of management practices
Proxy tests
Our farmer collaborators

- Valuable knowledge holders in the system
- Range of farm / soil types / management systems
The Results: Soil Organic Matter (so far)

Soil Organic Matter percentage

0-10cm
10-30cm
30-50cm

Horticulture – lots of compost

Highest PP field (SW)

Lowest OM%
Continuous arable, light

Agricultology
Sustainable Practical Farming
The Results: Proxy Tests (so far)

• Good correlation between aggregate stability and soil organic matter / carbon
• Infiltration – dependent on weather conditions, although visible differences in fields that have good soil health.
• Worms – seems to be more deep burrowing worms on fields that are not being cultivated, overall numbers – time of year / soil conditions
• Biological activity – will depend on soil / weather conditions
Soil Analysis for Soil Multi-functionality:
Structure, Chemistry, Biology, Yield

Typical soil make-up:
- 25% air
- 45% mineral matter
- 25% water
- 5% organic matter

Wheat:
- Wood
- Hedge
- Grassy margin
- Conventional Arable
- 2 m
- 32 m

Soil functional theme:
- Biological
- Chemical
- Physical

Hedge:
- Total nitrogen
- Earthworm numbers
- Mycorrhiza diversity
- Organic carbon
- Water storage
- Wheat growth
- Bulk density

Margin:
- Total nitrogen
- Earthworm numbers
- Mycorrhiza diversity
- Organic carbon
- Water storage
- Wheat growth
- Bulk density

Arable:
- Total nitrogen
- Earthworm numbers
- Mycorrhiza diversity
- Organic carbon
- Water storage
- Wheat growth
- Bulk density
Soil Multi-functionality

Hedge
- Total nitrogen
- Organic carbon
- Water storage
- Aggregate stability
- Water drainage
- Bulk density
- Wheat growth
- Mycorrhiza diversity
- Earthworm numbers

Marginal
- Total nitrogen
- Organic carbon
- Water storage
- Aggregate stability
- Water drainage
- Bulk density
- Wheat growth
- Mycorrhiza diversity
- Earthworm numbers

Arable
- Total nitrogen
- Organic carbon
- Water storage
- Aggregate stability
- Water drainage
- Bulk density
- Wheat growth
- Mycorrhiza diversity
- Earthworm numbers

Wheat bioassay: 58% yield increase in field trial
The role of hedgerows in soil functioning within agricultural landscapes

J. Holden\textsuperscript{a,}, R.P. Grayson\textsuperscript{a}, D. Berdahl\textsuperscript{b}, S. Bird\textsuperscript{c}, P.J. Chapman\textsuperscript{a}, J.L. Edmondson\textsuperscript{b}, L.G. Firbank\textsuperscript{d}, T. Helgason\textsuperscript{e}, M.E. Hodson\textsuperscript{e}, S.F.P. Hunt\textsuperscript{a}, D.T. Jones\textsuperscript{f}, M.G. Lappage\textsuperscript{g}, E. Marshall-Harries\textsuperscript{b}, M. Nelson\textsuperscript{c}, M. Prendergast-Miller\textsuperscript{e}, H. Shaw\textsuperscript{b}, R.N. Wade\textsuperscript{b}, J.R. Leake\textsuperscript{b}
Carbon is important but soil structure is arguably even more important for soil multifunctionality. Soil structure is very responsive to changes in management and to soil biology in particular. Improvements in earthworm numbers and mycorrhizal fungal activity increases water-stable aggregates, and these help to store organic carbon.
<table>
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<th>Year</th>
<th>Crop</th>
<th>Org. Mtr</th>
<th>pH</th>
<th>P</th>
<th>K</th>
<th>Mg</th>
<th>Crop</th>
<th>Org. Mtr</th>
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</table>
DOC trial SOM

(high intensity plots only)

Udvikling i jordens indhold af kulstof (høj gødningsniveau)

Key practices to improve soil health and productivity

• Maintain good **soil structure** and drainage
• Reduce **tillage** and depth of ploughing to a minimum
• Use a good **crop rotation** with high crop diversity
• Use **cover crops** for continuous ground cover
• Use green manures to maximise **carbon** return to the soil — feed the soil organisms
• Include **legumes** in the rotation to fix N and enhance soil microbial activity
• Use livestock **manure** efficiently to **recycle nutrients**, add carbon to encourage fungi and provide soluble nutrients
• There are indications to **compost** manure or vegetable waste for high biological activity, carbon accumulation and healthy crops
• **Maintain pH** ideally in range 6.3 - 7
• Use **mineral fertilisers** to ensure sufficient macro and micro nutrient levels and availability for soil microbe, plant, animal and human health
• Use soil amendments and **inoculants** where they are shown to be effective e.g. rhizobia inoculants.
• **Avoid agrochemicals** that suppress soil biological activity e.g. Ivomectin, Glyphosate, super phosphate, nitrogen fertiliser, nematicides