Knowing your soils: Practical soil analysis and monitoring



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The University Of Sheffield.

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eip-agri

Soil analysis methods

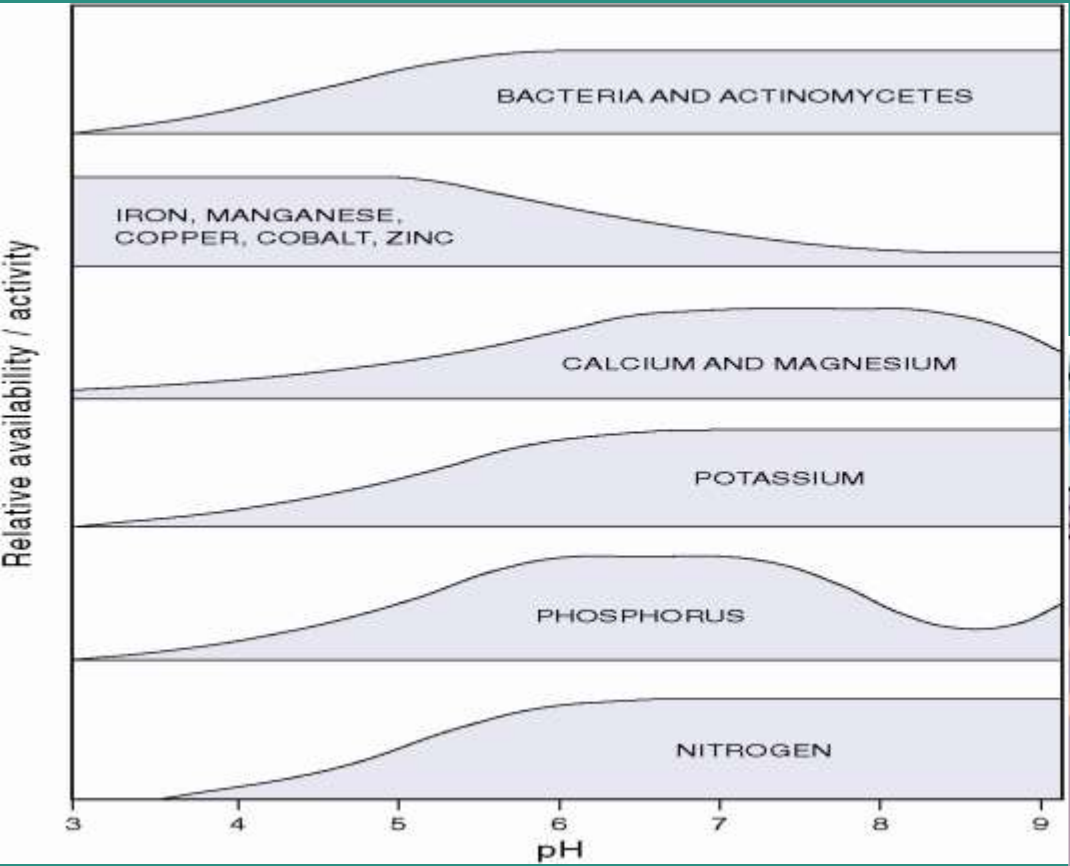
Mark Measures

Organic Research Centre

- **Soil EIP Project**
- Winston Churchill Fellowship 2017/18

https://info925698.wixsite.com/mark-measures

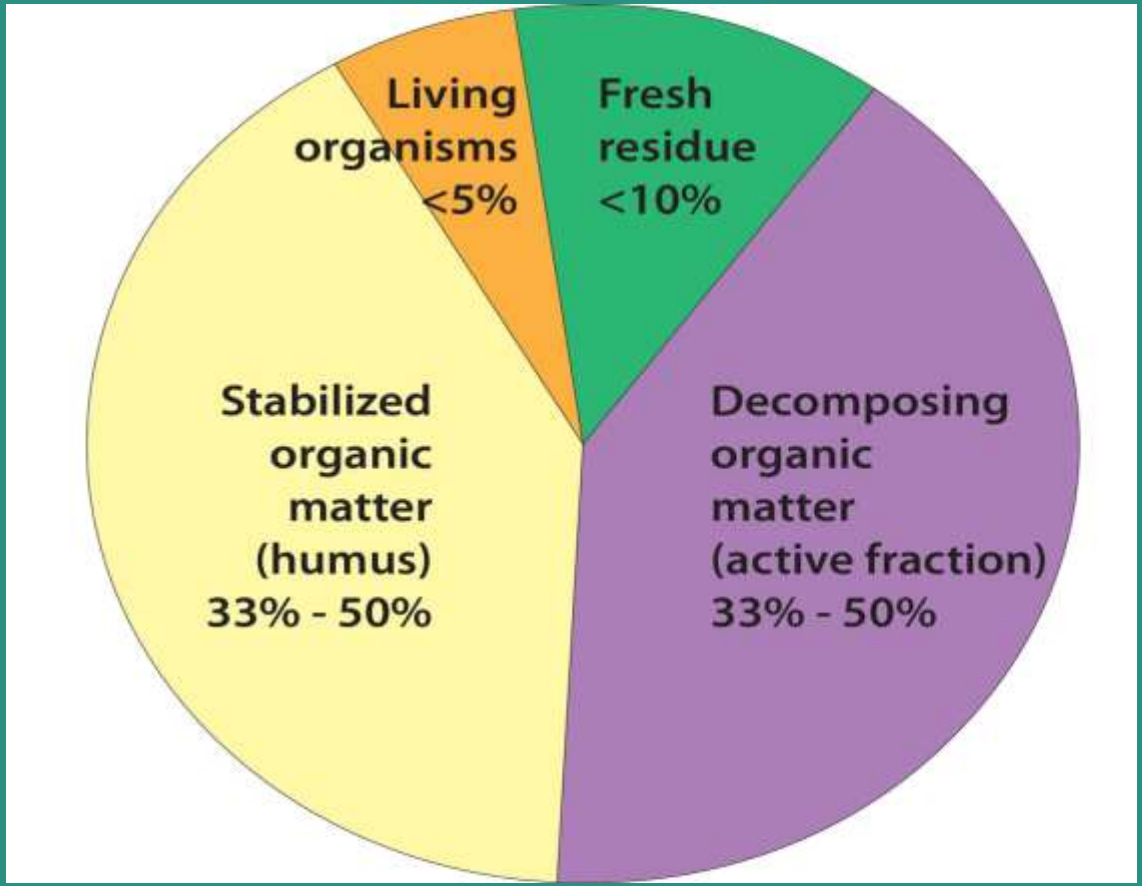
Standard analysis: pH, P, K, Mg



HOSPHORUS		POTASSIUM		MAGNESIUM	
sen extraction		Ammonium nitrate extraction			
Olsen P		exchangeable K		exchangeable Mg	
x	mg/l	Index	mg/l	Index	mg/l
	0-9	0	0-60	0	0-25
	10-15	1	61-120	1	26-50
	16-25	2-	121-180	2	51-10
		2+	181-240		
	26-45	3	241-400	3	101-17
	46-70	4	401-600	4	176-25
	71-100	5	601-900	5	251-35
	101-140	6	901-1500	6	351-60
	141-200	7	1501-2400	7	601-10
	201-280	8	2401-3600	8	1001-15
	over 280	9	over 3600	9	over 15

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:
    - Available Water Capacity
    - Surface Hardness
    - Subsurface Hardness
    - Aggregate Stability

- Biological
    - Organic Matter
    - Soil Respiration
    - (Soil Protein)
    - (Active Carbon)

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

- **Inform overall management rather than fertiliser inputs.**

Photo: Agroscope

Albrecht/Base Cation Saturation Ratio

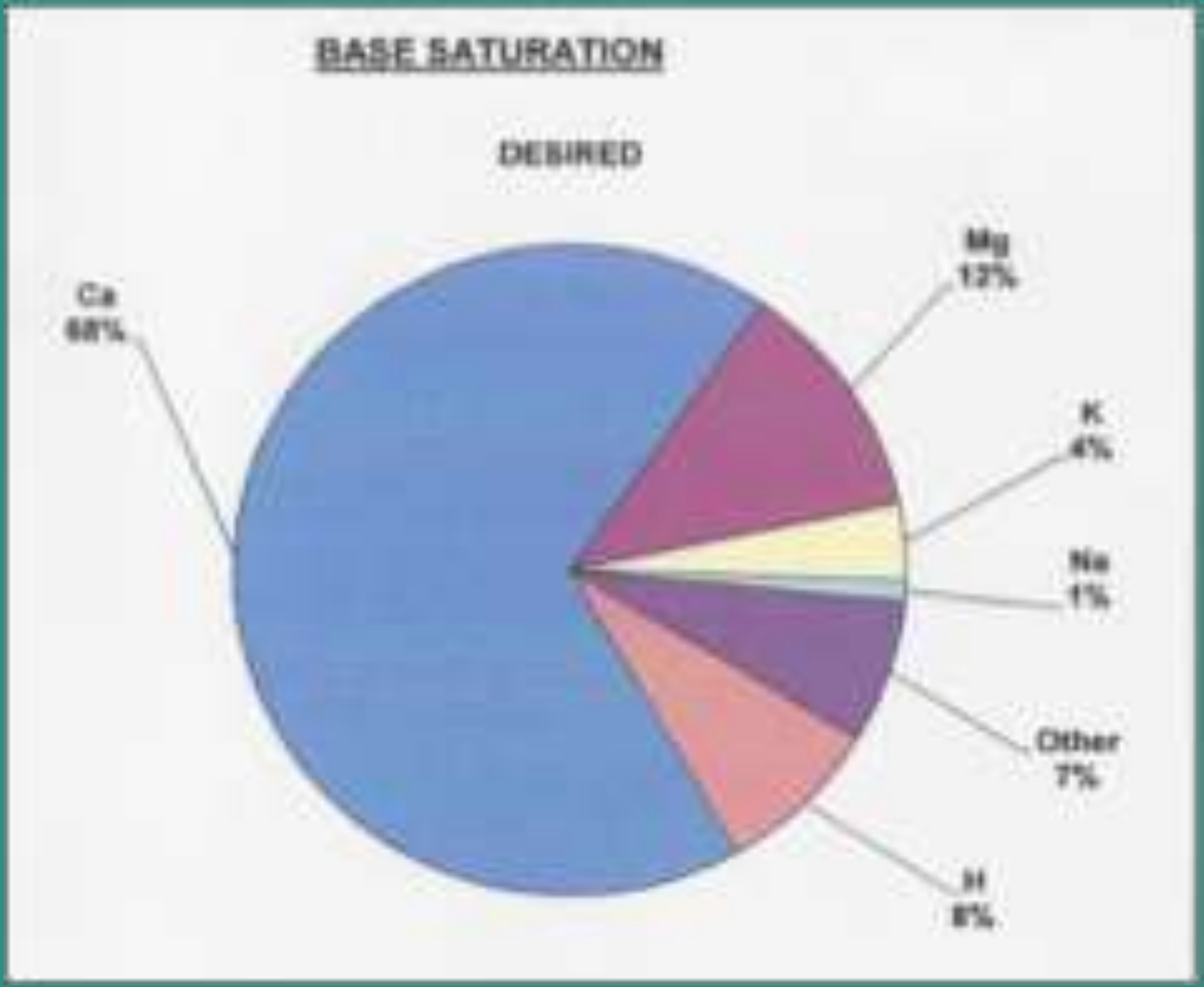
pH, SOM, Macro and Trace elements, P reserves, CEC, BCSR, (Biology)

- 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**

ANALYSIS		RESULT	INTERPRETATION					COMMENTS
			Deficient	Low	Normal	High	Excessive	
Nitrogen (N)	*[N:S Ratio]*	1.44 %						N is deficient. Possible causes: low N application, low soil available-N, low soil P.
Sulphur (S)	*[15.1 : 1]*	0.095 %						S is deficient. Possible causes: low soil Sulphate, excess soil N on low organic matter soils, low S fertilisation, high leaching.
Phosphorus (P)		0.359 %						Nutrient status satisfactory.
Potassium (K)		1.82 %						K is deficient. Possible causes: low soil K, low K application excessive N applied, cold wet spots.
Calcium (Ca)		0.273 %						Nutrient status satisfactory.
Magnesium (Mg)		0.074 %						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.
Manganese (Mn)		54.7 mg/kg						Nutrient status satisfactory.
Iron (Fe)		78.1 mg/kg						Nutrient status satisfactory.
Copper (Cu)		6.21 mg/kg						Nutrient status satisfactory.
Zinc (Zn)		21.7 mg/kg						Zn is low. Possible causes: low soil Zn, high soil pH leaching, high soil P, low soil organic matter.
Boron (B)		2.44 mg/kg						B is deficient. Possible causes: low soil B, high soil pH, highly leached sandy soils or low organic matter soils.

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**

Testing soils for carbon

- 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

The Soil Carbon Project

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

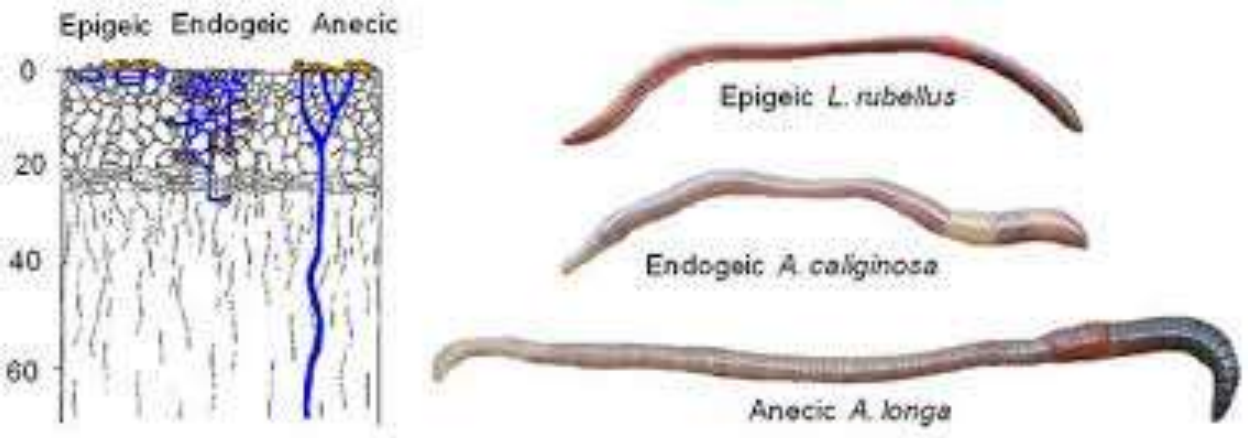


Figure 1. Assessment of appearance of air-dry peds in artificial effluent (SAR 5; EC 1 dS/m).

Game & Wildlife Conservation Trust
The Allerton Project

Organic Research Centre
Elm Farm

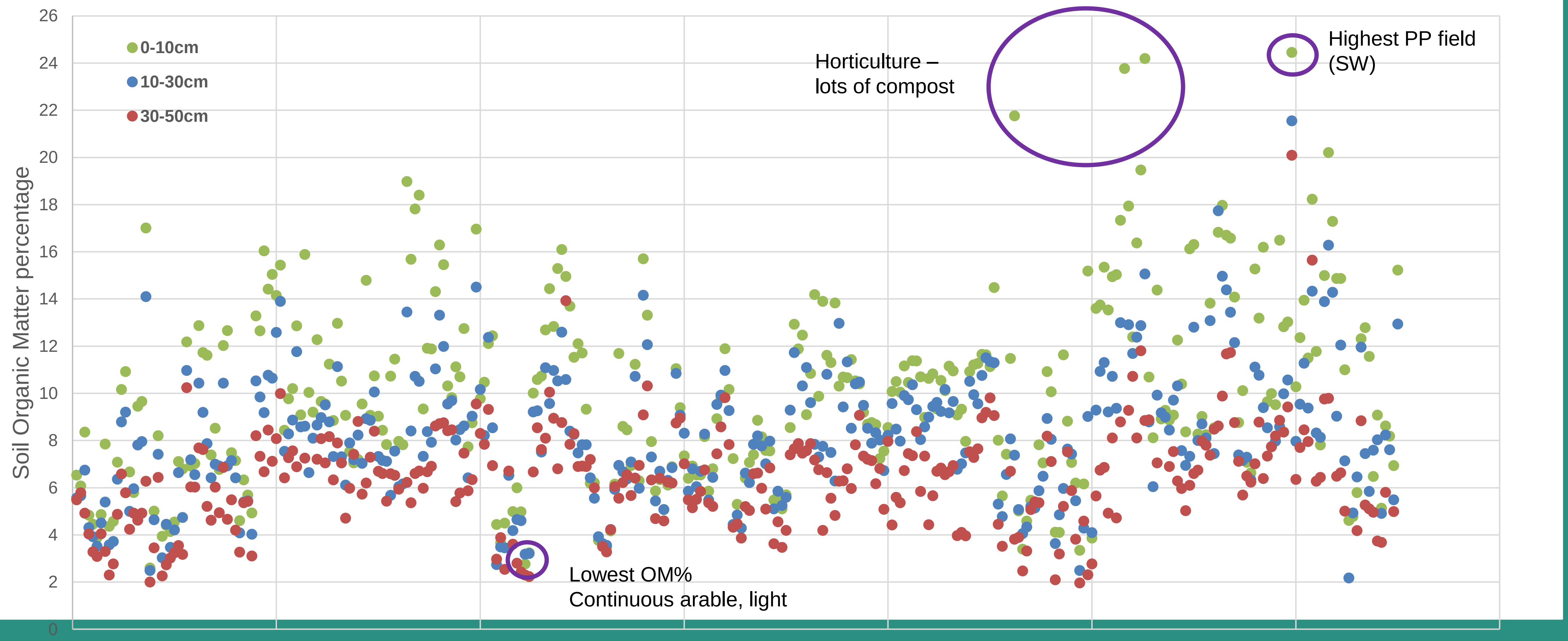
Our farmer collaborators

- Valuable knowledge holders in the system
- Range of farm / soil types / management systems






The Results: Soil Organic Matter (so far)

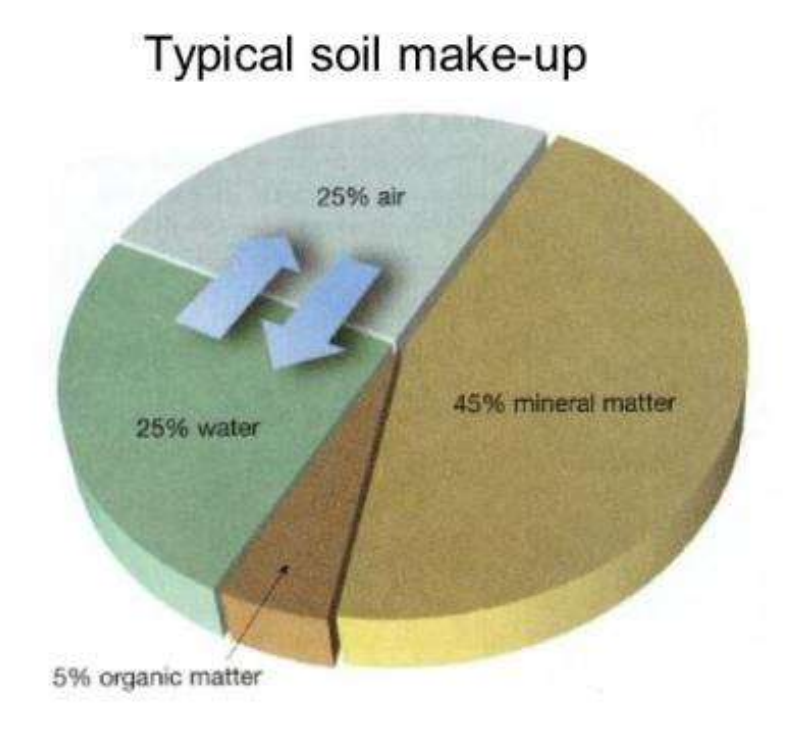


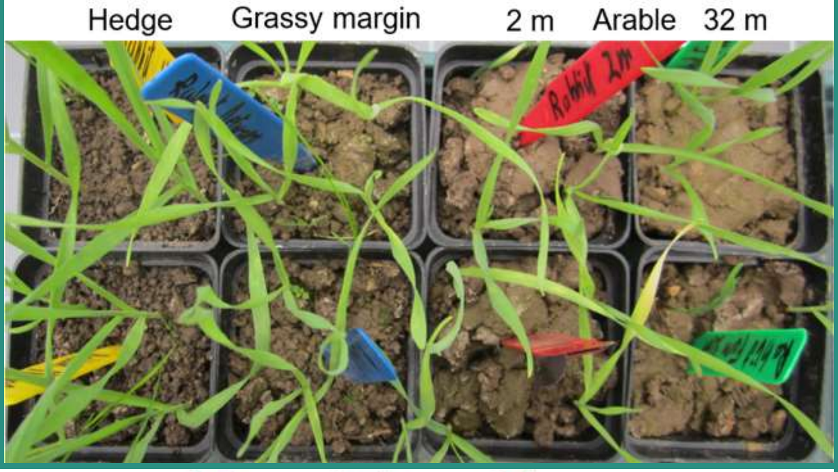
The Results: Proxy Tests (so far)

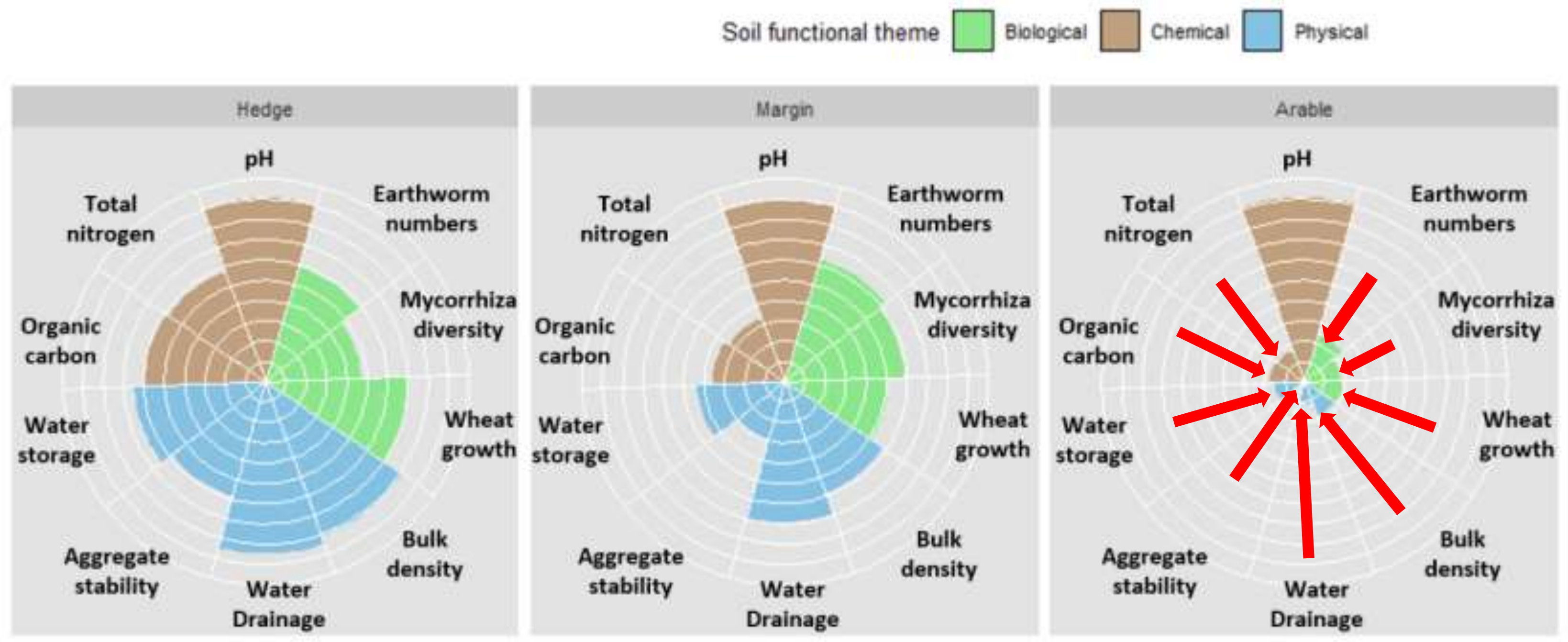
- Good correlation between aggregate stability and soil organic matter / carbon
- Infiltration – dependent on weather conditions, although visible differences in fields that have good soil health.
- Worms – seems to be more deep burrowing worms on fields that are not being cultivated, overall numbers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

Jonathan Leake

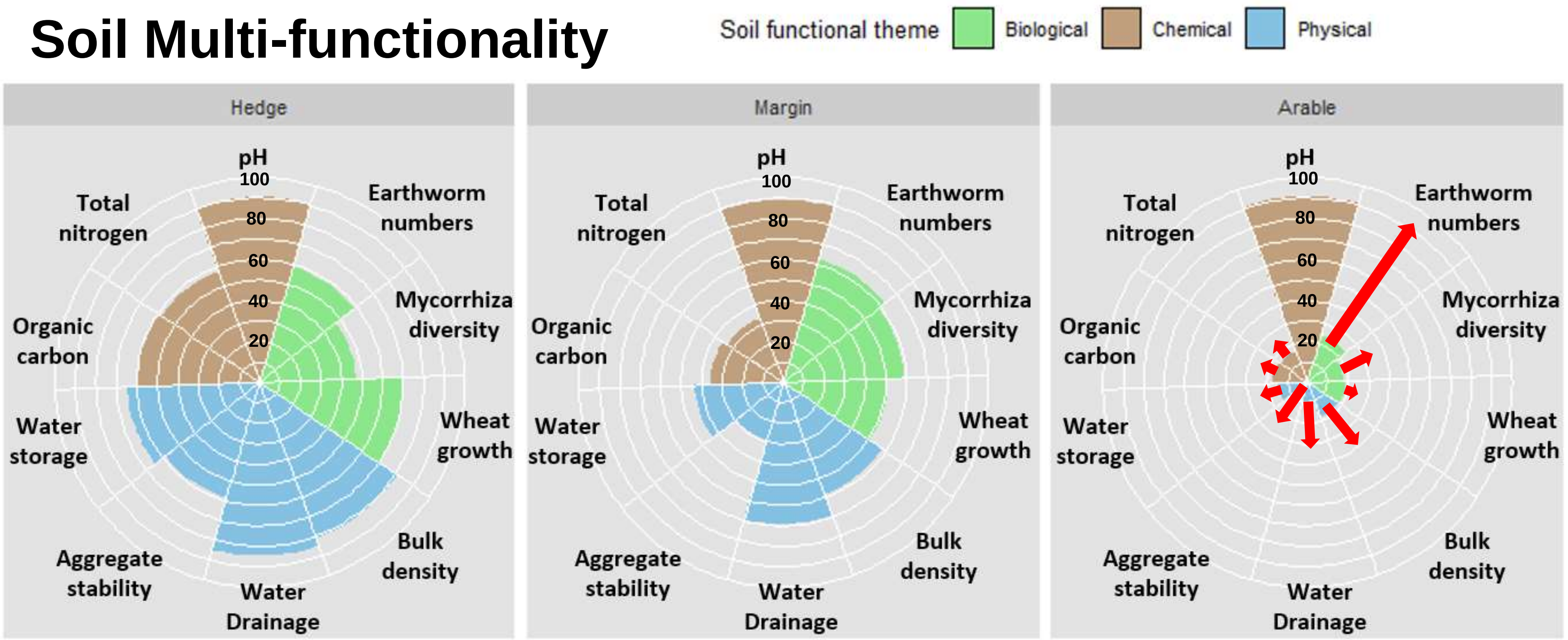
Soil Analysis for Soil Multi-functionality: Structure, Chemistry, Biology, Yield

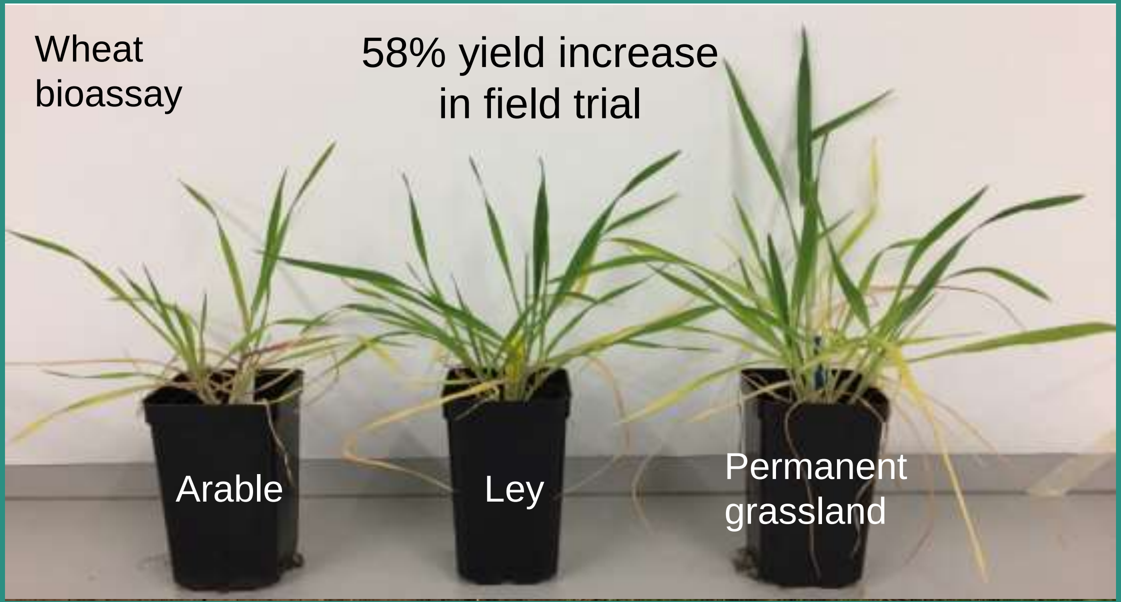






Soil Multi-functionality





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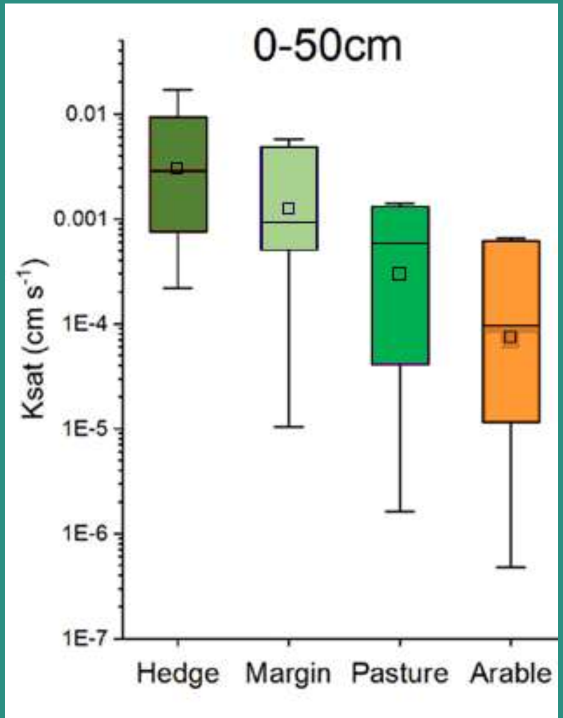
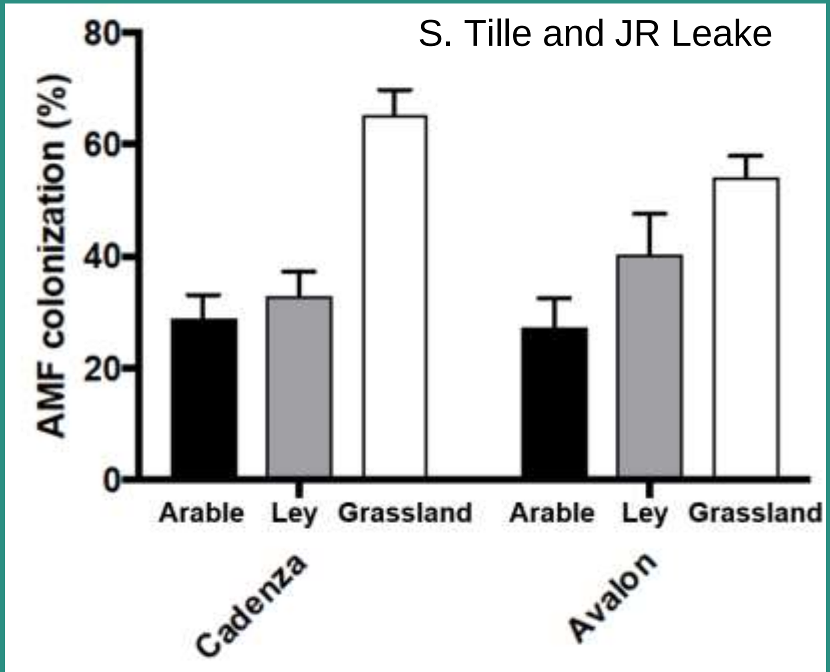
The role of hedgerows in soil functioning within agricultural landscapes

J. Holden[a,*], R.P. Grayson[a], D. Berdeni[b], S. Bird[c], P.J. Chapman[a], J.L. Edmondson[b], L.G. Firbank[d], T. Helgason[c], M.E. Hodson[e], S.F.P. Hunt[a], D.T. Jones[f], M.G. Lappage[d], E. Marshall-Harries[b], M. Nelson[c], M. Prendergast-Miller[e], H. Shaw[b], R.N. Wade[b], J.R. Leake[b]





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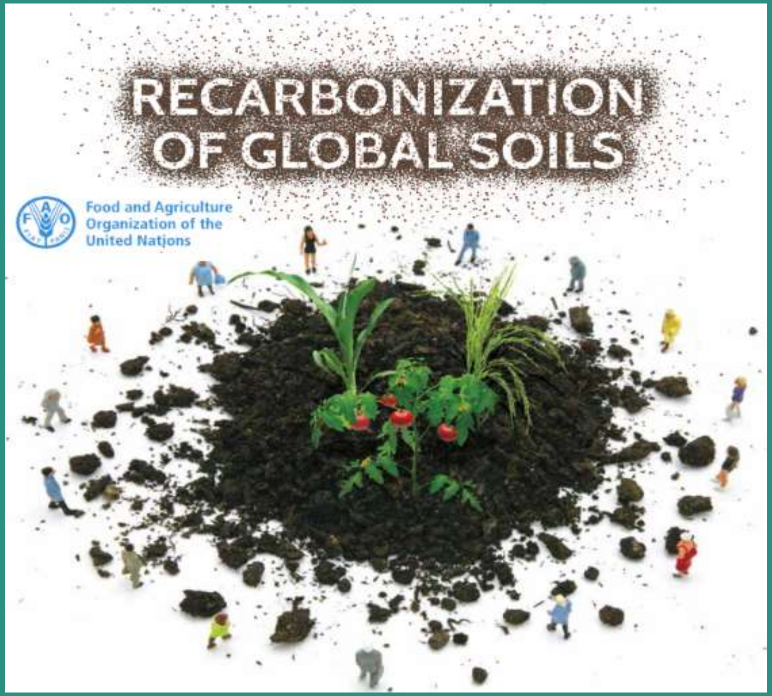
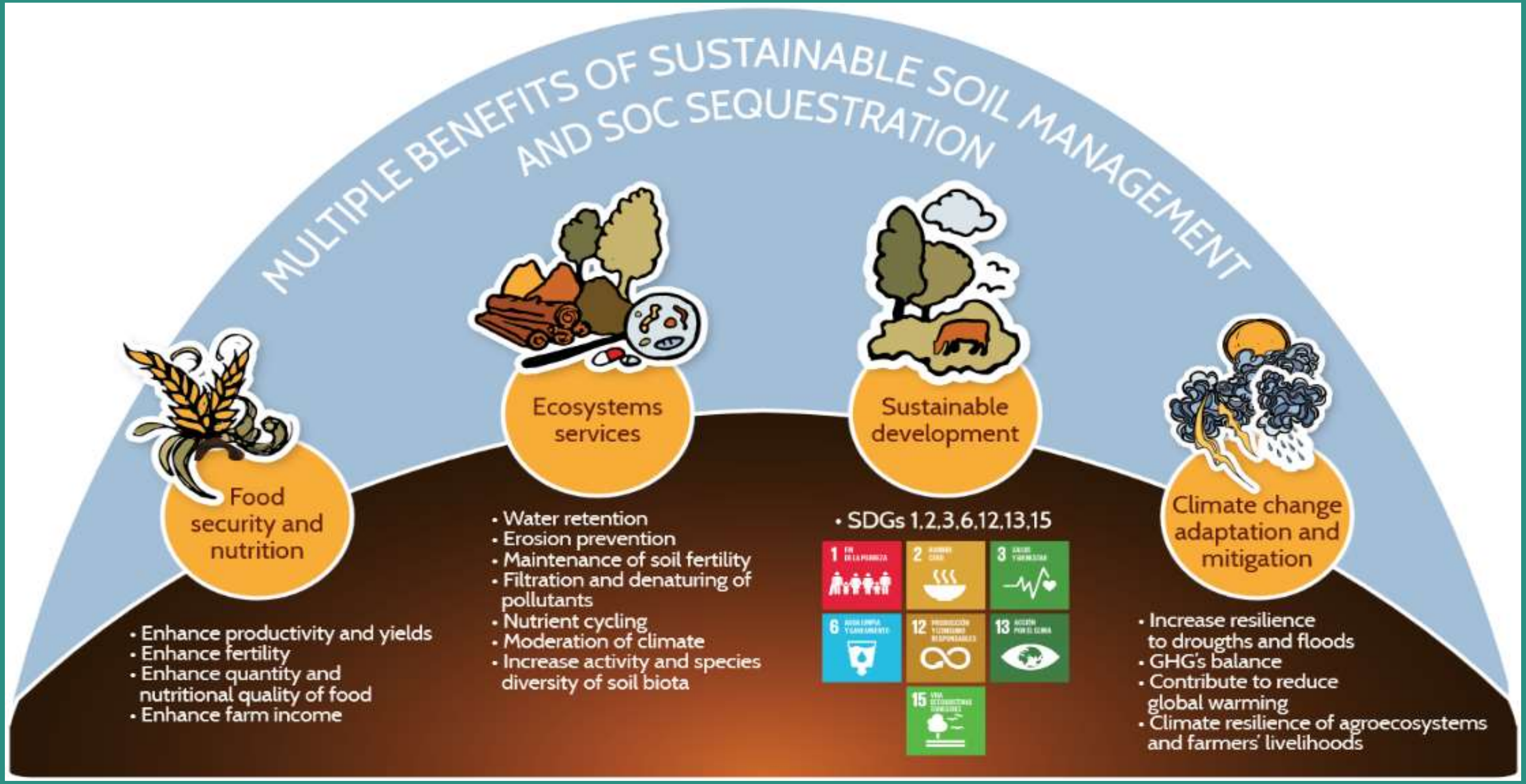
Carbon is important but soil structure is arguably even more important for soil multifunctionality.
Soil structure is very responsive to changes in management and to soil biology in particular.
Improvements in earthworm numbers and mycorrhizal fungal activity increases water-stable aggregates, and these help to store organic carbon.





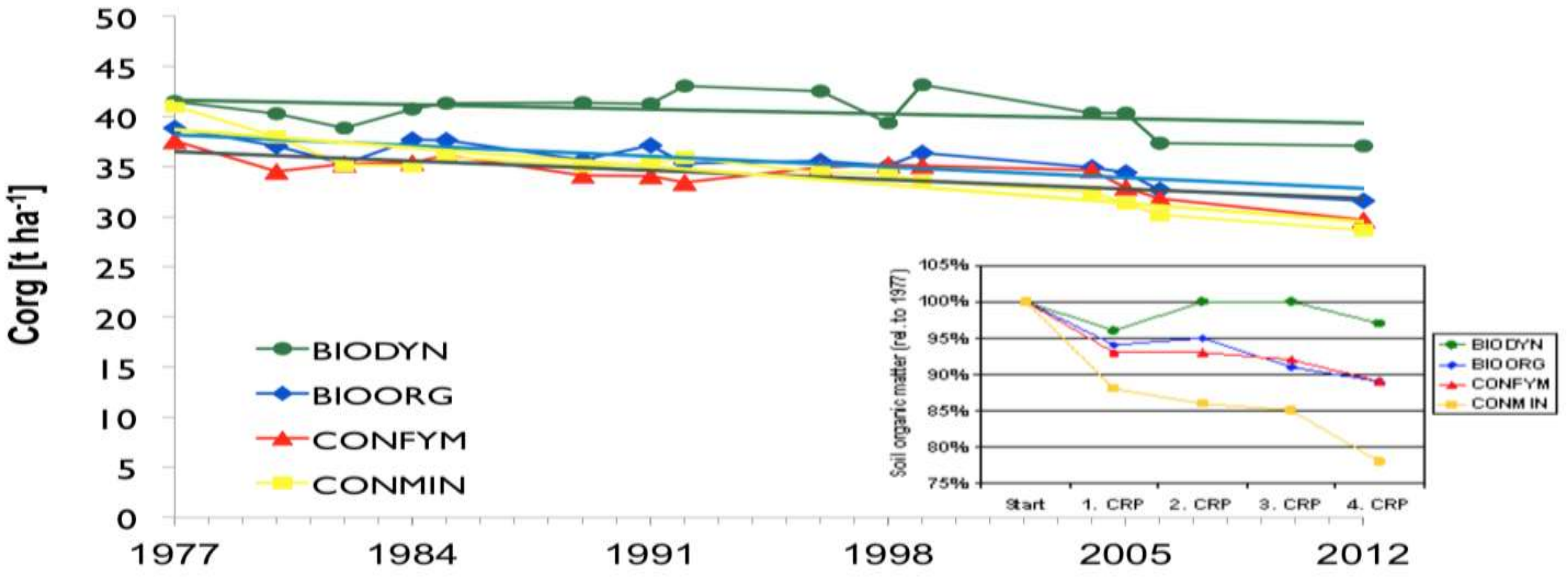
Soil analysis change over 14 years: Holme Lacy College

		Park House						Mill Field				
	Crop	Org. Mtr	pH	P	K	Mg	Crop	Org. Mtr	pH	P	K	Mg
2001	WBly	2.6	6.5	3	1	3	S. Beet	2.5	6.7	4	2-	4
2003	RCL	4.7	6.5	2	1	3	Trit	3.2	7.1	3	2-	4
2004	Wht	3.5	6.6	2	1	2	RCL	6.7	6.7	3	1	4
2005	SBly	-		3	1	4		-	-	-	-	-
2007	WCL	2.2	6.6	2	1	3	Wht	2.7	6.6	3	1	4
2009	Pots	2.6	6.6	2	1	3	RCL	2.4	7	3	2+	4
2010	Wht	2.8	6.7	3	1	3	Oats	-	-	-	-	-
2012	Pea/bly	2.9	6.4	3	2-	3		3.1	6.6	3	2-	4
2014	Wheat		6.4	3	1	3	Wheat		6.3	3	2	4

DOC trial SOM

(high intensity plots only)

Udvikling i jordens indhold af kulstof (høj gødningsniveau)



Fließbach, A. et al. 2007. Soil organic matter and biological soil quality indicators after 21 years of organic and conventional farming. Agric. Ecosys. Environ. 118, 273-284

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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 supress soil biological activity e.g. Ivomectin, Glyphosate, super phosphate, nitrogen fertiliser, nematicides