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Smart land use:
Carbon sequestration through farming practices and their effects on soil quality

Chris Koopmans,

Jonas Schepens & Bart Timmermans

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WAGENINGEN UNIVERSITY & RESEARCH

clm Centrum voor Landbouw en Milieu

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Policy background

Paris Agreement
- < 2° degrees and aim for 1.5 degrees
- After 2050: net zero emissions

EU policy
- -55% emission reduction in 2030
- Land use and carbon (C)-sequestration in soils count

Climate Agreement of the Netherlands (2019)
- In agriculture and land use a reduction of 3.5 Mton CO2-eq. per year from 2030 onwards
- *Mineral soils: 0.5 Mton CO2-eq. per year from 2030 onwards*

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Smart Land use Program

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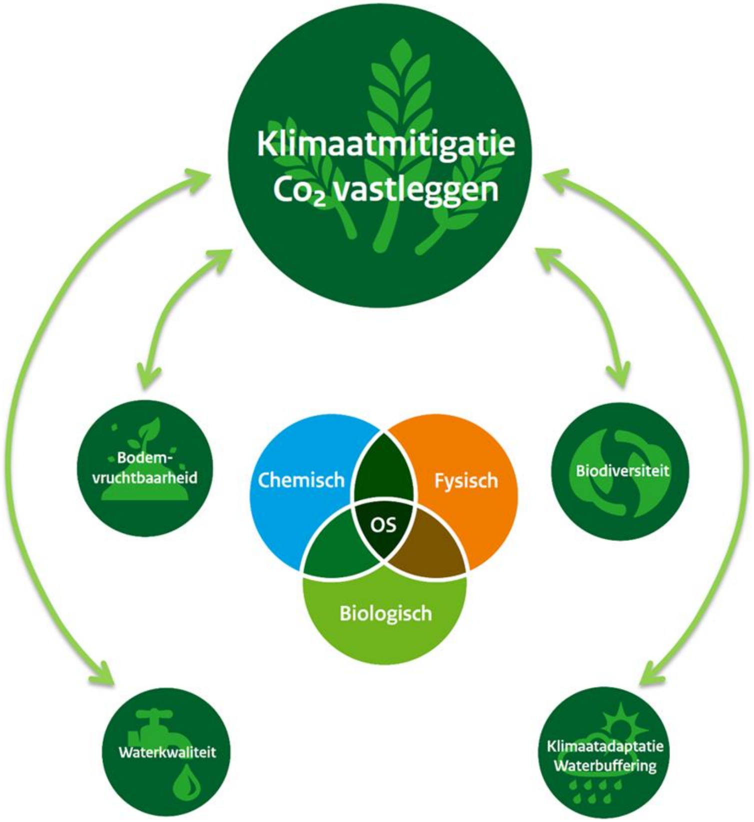

Aims at:

- Determining reference carbon stocks in soils (2018)
- **Evaluating the effectiveness of carbon sequestration through farmer practices on mineral soils**
- Improving options for implementation of practices at the farm level - networks
- Monitoring progress towards the goals of 0.5 Mton/year
- Stimulate farmers by policies and incentive options

All within a policy goal of a sustainable soil management on all agricultural soils by 2030!

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Evaluating practices for carbon sequestration

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Three-step approach:

- Determine the effectiveness of the carbon sequestration of agricultural practices for Dutch agriculture in Long Term Experiments (LTE's).

- Combine the effectiveness with the potential (hectares) to determine the contribution to the target of 0.5 Mton CO_2 reduction per year.

- Determine whether and how (positive, neutral or negative) practices impact soil quality characteristics.

Potential used in Climate Agreement

Practice	Max. per ha	Max. Potential	Implemen-tation	Realistic potential
	ton CO_2/ha/jaar	kton CO_2/jaar	%	kton CO_2/jaar
Non-inversion tillage	0.6	475	50	238
No-tillage	1.2	912	20	182
Cover crop	0.4	311	50	156
Improving rotation	1.2	942	20	188
Crop residues	0.8	628	20	126
Field margins	0,1	145	40	58
Permanent pastures	3.6	710	30	213
Total				**790**

Lesschen et al., 2012

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Which practices are evaluated?

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Arable land:
- Adaptation of crop rotations (with cereals, grassclover, alfalfa etc.)
- Replacing art. fertilizers by solid manure and compost
- Use of cover crops
- Crop residues
- Uncultivated field margins
- Replacing ploughing by Non-inversion tillage

Livestock farming
- Increasing pasture age (Non-ploughing)
- Maize-grass rotation (replacing continuous maize)
- Replace mono-pastures by biodiverse pastures (including herbs)
- Non-inversion tillage in maize after grass

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Evaluation of practices in Long-Term Experiments

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- Selection of LTE's comparing treatments <u>with</u> and <u>without</u> the farming practices
- Duration of the LTE preferably > 7 years
- About 200 treatments per year since 2018 (2 depths: 0-30 en 30-60 cm).
- Insight into the effectiveness of the practices for C-sequestration and linkage with soil quality indicators

Indicator	Measurement	Depth (cm) 0-30	30-60
Carbon	Carbon- Dumas	x	x
Farmer fields	O.S. – Near Infra Red	x	x
	O.S. – loss on ignition	x	x
Soil quality indicators	Chemical	x	
	Physical	x	
	Biological	x	

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Adaptation of crop rotations

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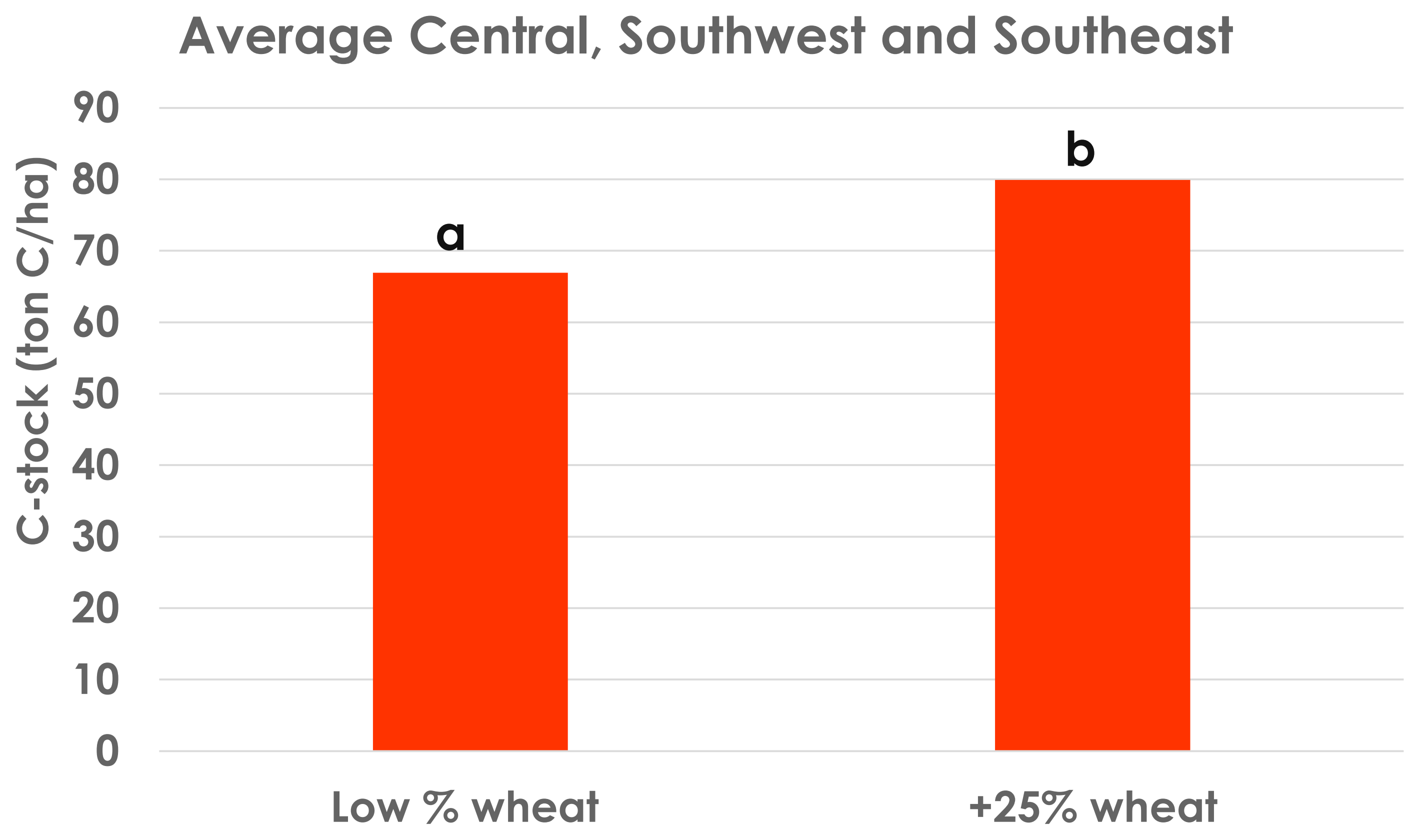
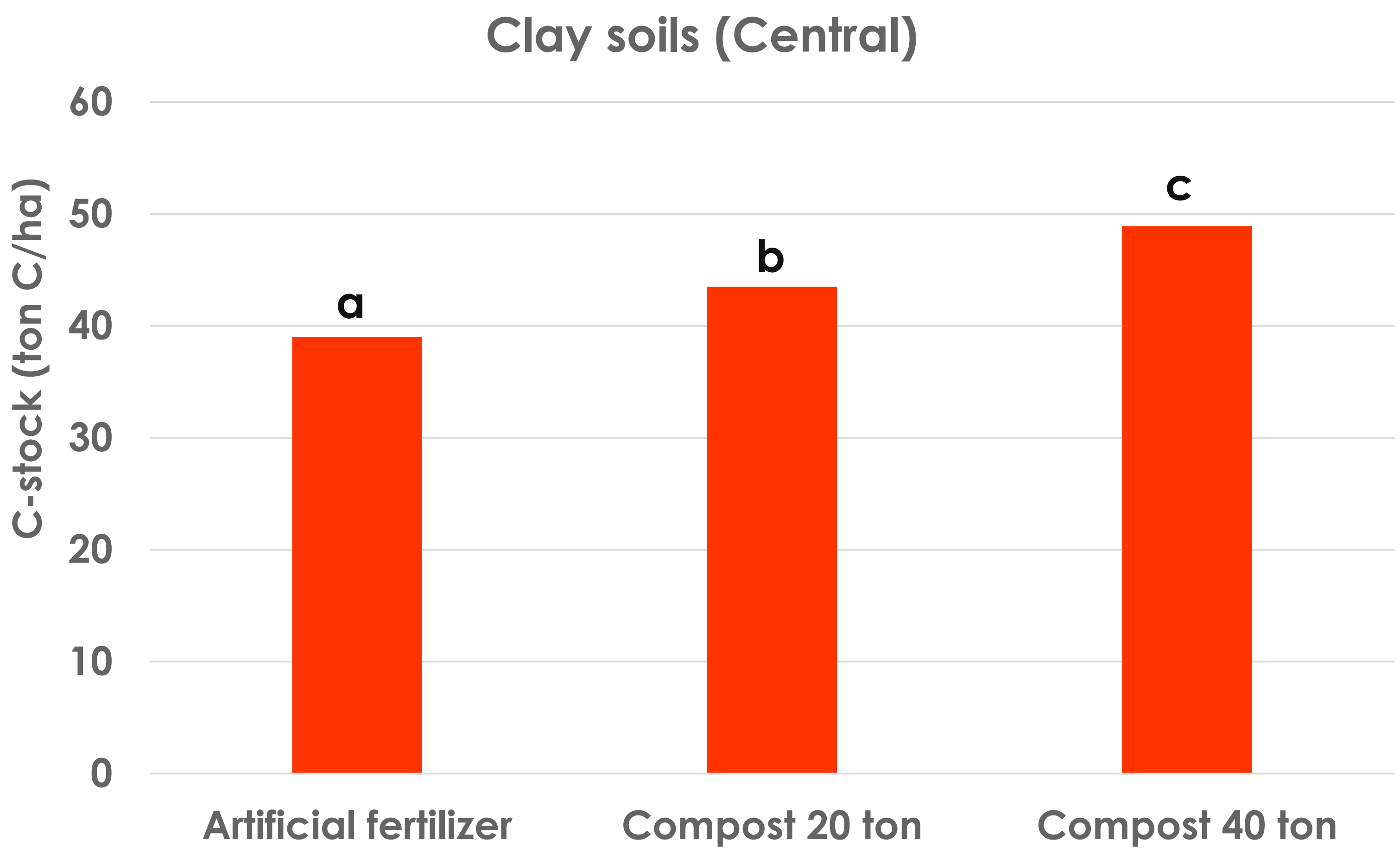


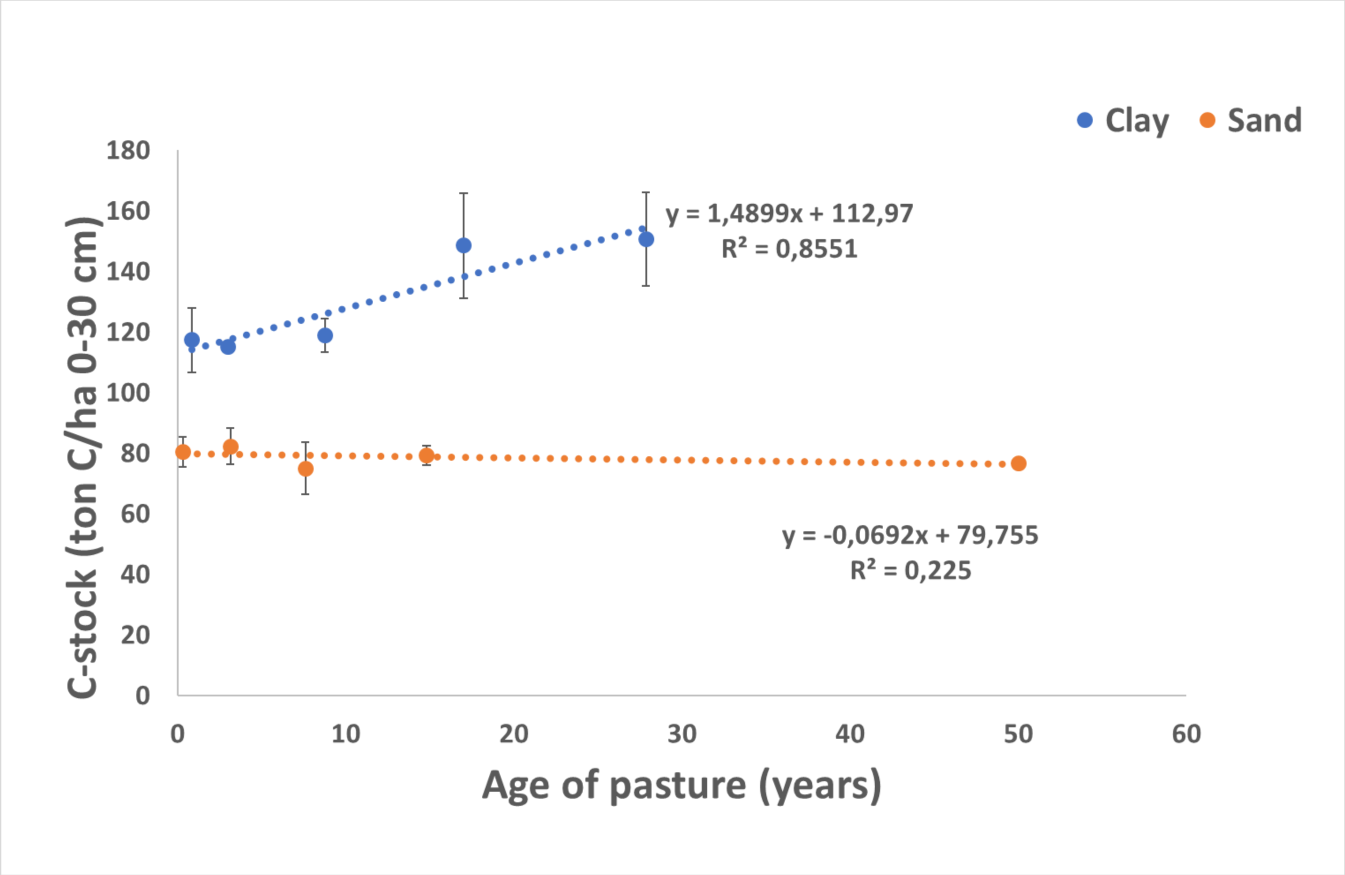
An analysis combining three regions shows differences ($p<0.05$) in C-stock due to more cereals in rotation.

Replacing fertilizers with compost



Significant differences (P< 0.05) in C-stock due to compost use.

Increasing pasture age
(non-ploughing of pasture)



In northern clay soils a significant increase in C-stock with increasing age of the pasture.
No significant increase in pastures on sandy soils in the south.

Total CO_2-potential simulated

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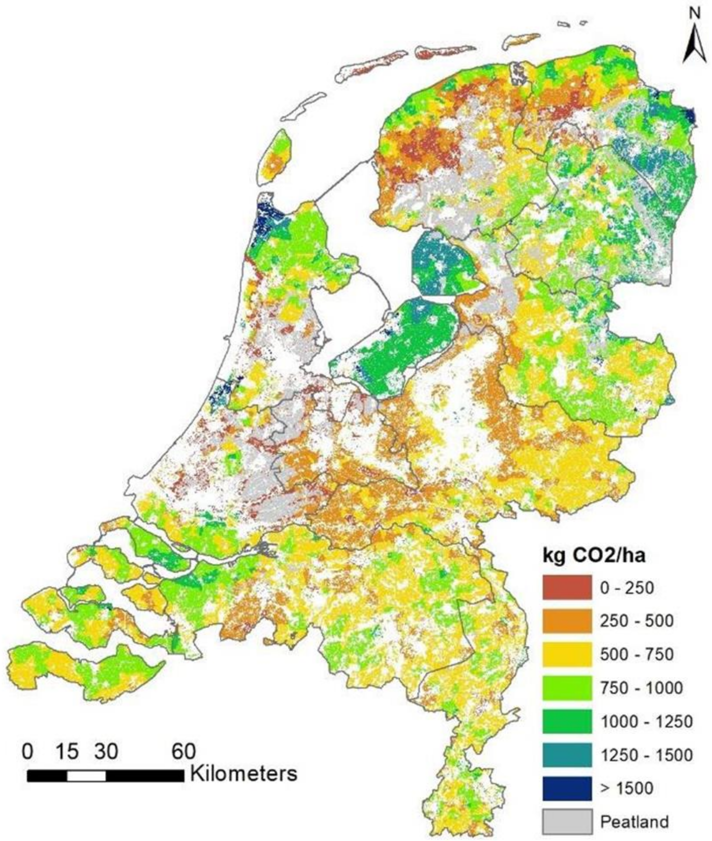
Model simulation (RothC) indicate a total CO2 sequestration potential for the Netherlands of 0.9 Mton per year in mineral soils (Lessen et al., 2021).

Clay soils				
Practice	Max. CO_2-sequestration[1]	Implementation	Potential CO_2-seq.	N_2O emission
	kg CO_2/ha/year	x1000 ha	kton CO_2/year	+/-
Cover crops	1440	89	128	-/+
Improving crop rotation	3250	35	113	+
Solid manure and compost	85	1150	102	-/0
Permanent pastures	1590	51	82	-/+
Crop residues	660	114	76	-/+
Maize-grass rotation (60-20-20)	1450	24	34	-/+
Non-inversion tillage	0	-	0	-/+
Biodiverse pastures	0	-	0	0/+
Field margins	-70	8	-1	0/+

[1] Based on Roth-C model simulations by Lesschen et al., 2021



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Do practices impact soil quality characteristics and contribute to a sustainable soil management?

Standardised soil quality indicators for the Netherlands

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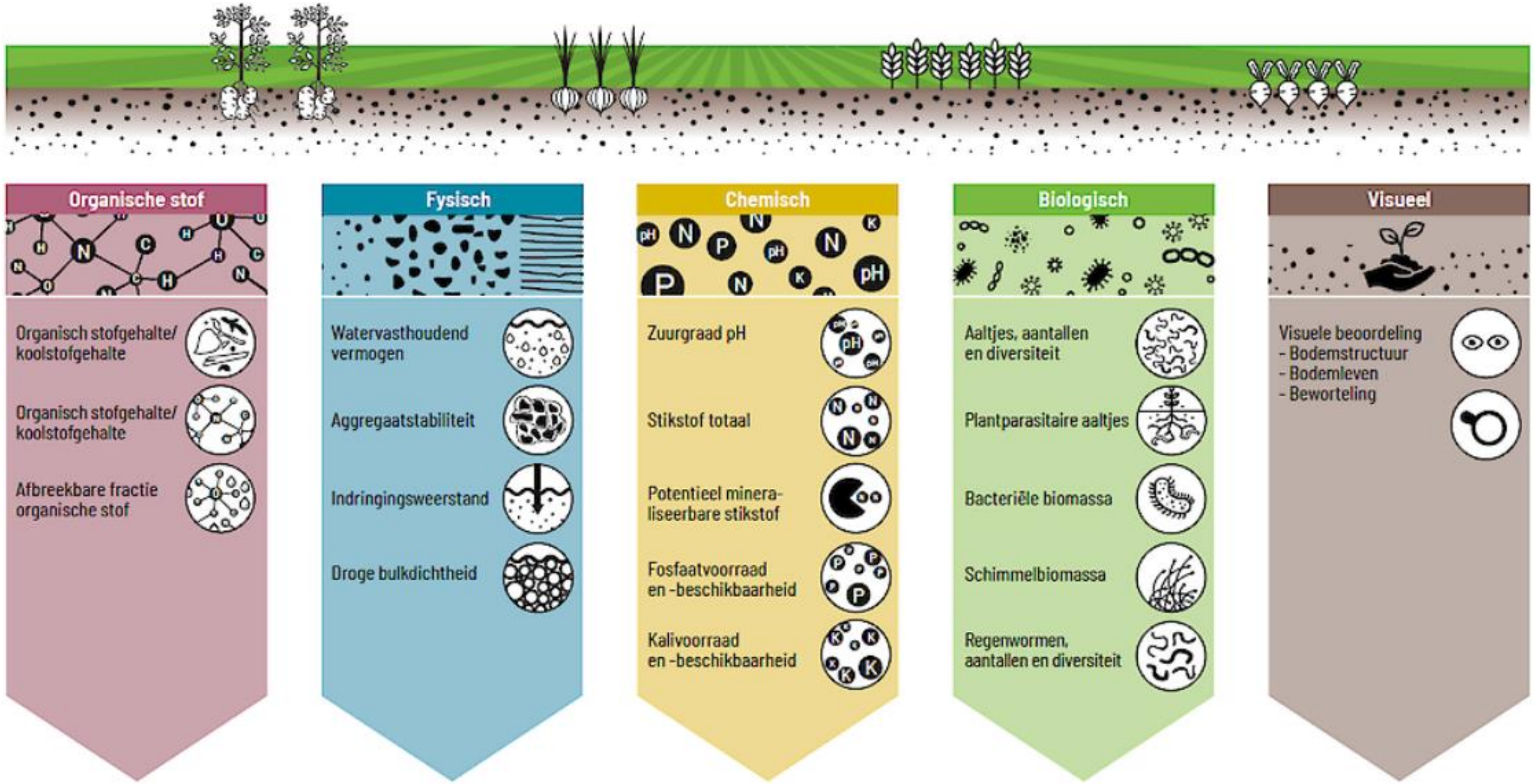

Organic matter | Physical | Chemical | Biological | Visual

Soil quality effects

green = significant positive effect

		Organic matter OM, Total-C, HWC	Physical Bulk Density	Chemical N, P, K content	Water Water Holding Capacity	Biological Fungal and bacterial biomass
Adaptation of crop rotation	Sand	+	+	0	0	+
	Clay	+	+	+	0	+
Solid manure and compost	Sand	NA	NA	NA	NA	NA
	Clay	+	+	+	0	0
Cover crops	Sand	0	+	0	0	0
	Clay	NA	NA	NA	NA	NA
Non-inversion tillage	Sand	0	+	0	+	0
	Clay	0	+	0	0	0
Permanent pastures	Sand	+	+	0	0	+
	Clay	+	+	+	+	+
Field margins	Sand	0	+	+	0	0
	Clay	+	0	+	0	+
Maize-grass rotation	Sand	+	+	+	0	0

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Conclusions

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- Agricultural practices have the potential to contribute to carbon sequestration with a total potential of about 0.9 Mton CO_2 per year in mineral soils of the Netherlands
- Effective practices that contribute most are:
  - a switch from arable farming to permanent pastures;
  - use of cover crops;
  - arable rotations with additional cereals (grassclover, alfalfa etc.);
  - replacement of art. fertilizer by compost or solid manure;
  - a change to maize-grass rotations.
- Practices have a significant positive impact on certain soil quality indicators which indicates they also contribute to a sustainable soil management.