UCLouvain
Earth and Life Institute (ELI)

Depicting the effect of tillage treatments and vehicle traffic on the agricultural soil physical quality with a high level of spatial details

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JORNADAS INTERNACIONALES DE INVESTIGACIÓN

by the Institute for Innovation & Sustainable Development in Food Chain

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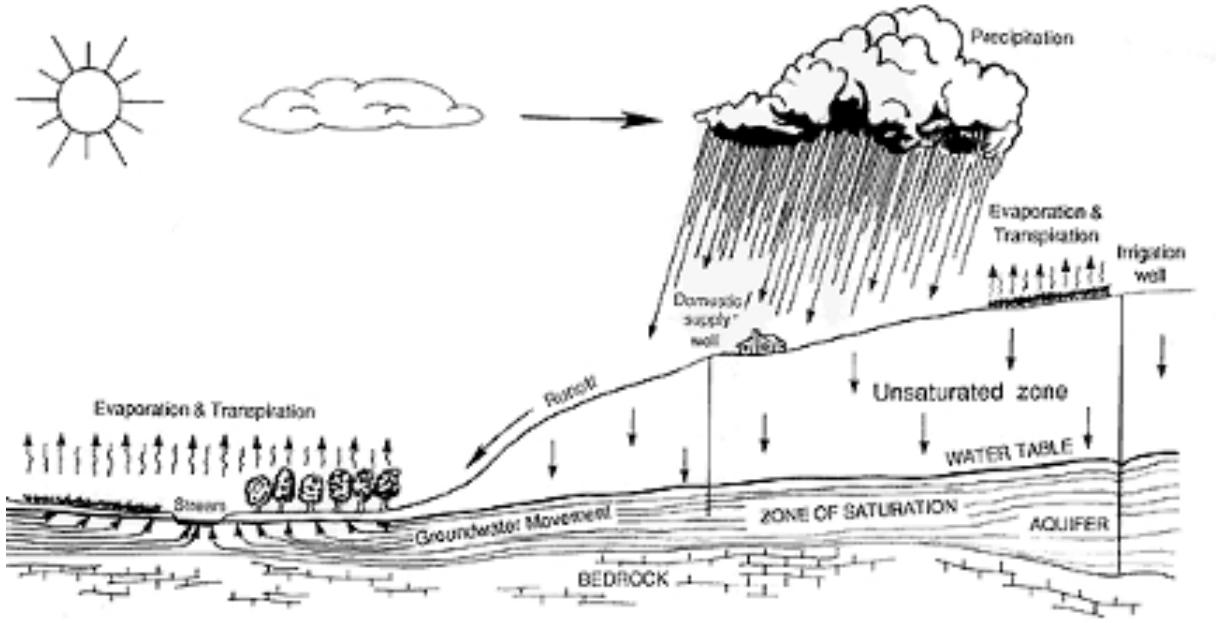
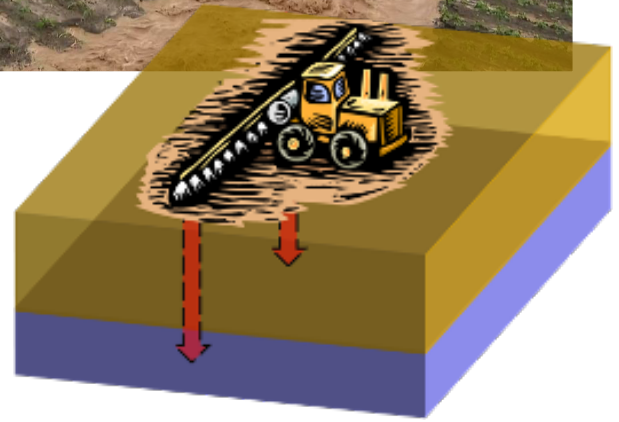
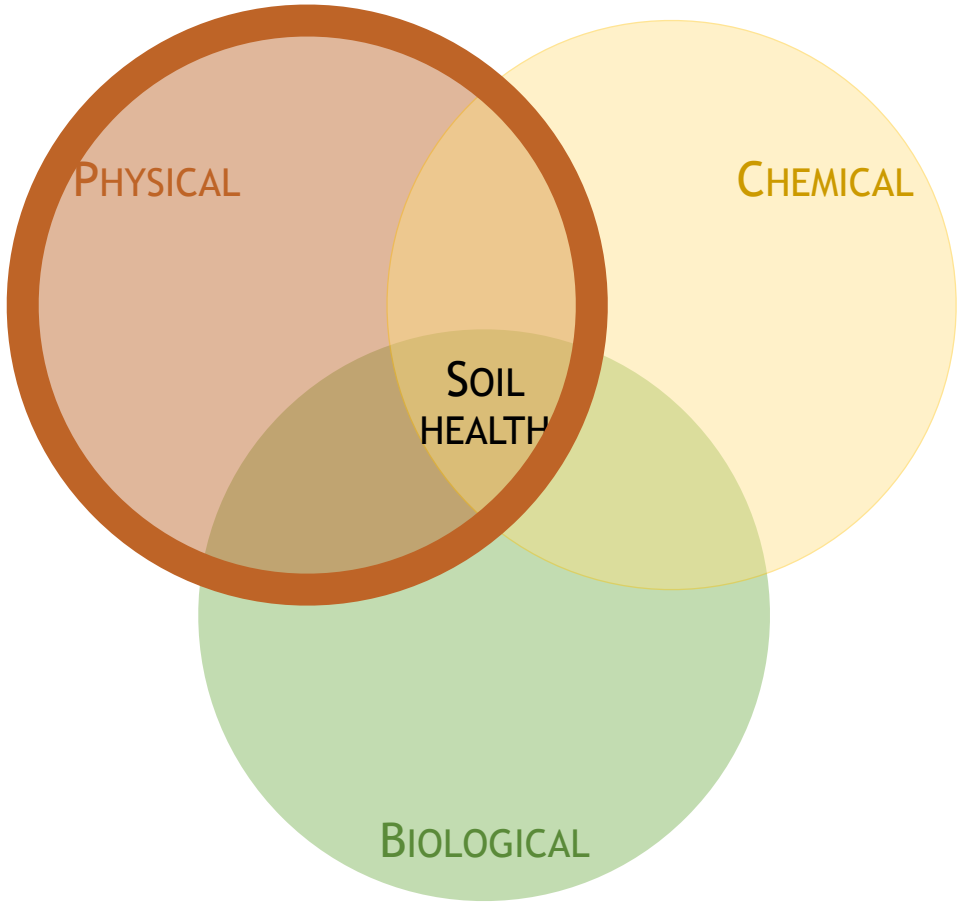
Healthy agricultural soils are vital …



… yet they are under great pressure



Reliable assessments of SOIL HEALTH are needed



Reliable assessments of SOIL PHYSICAL QUALITY are needed

Soil Structure

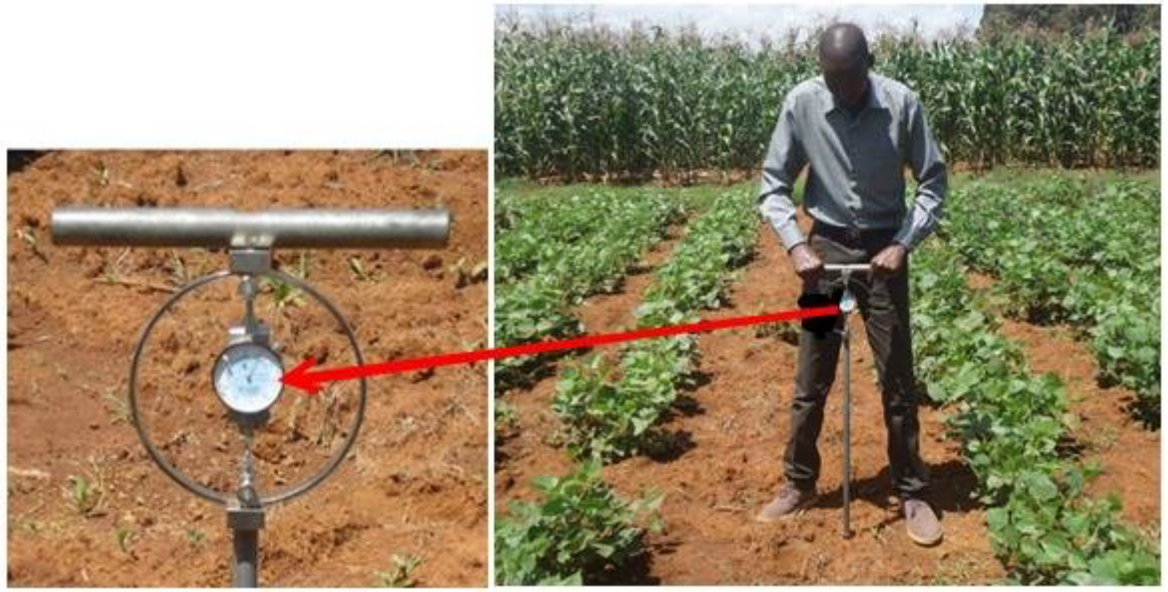
➡ Shape, size and spatial arrangement of primary soil particles and aggregates, and the resulting pore network

➡ Controls rooting conditions, air and water fluxes and stocks, and regulates the habitat for soil organisms

➡ Defined by abiotic, biotic and management-related factors

➡ Management-induced soil structural features are determining in the regulation of soil hydrologic response but are often poorly considered

Most methods are not representative of HETEROGENEITY…



… or their assessment is limited

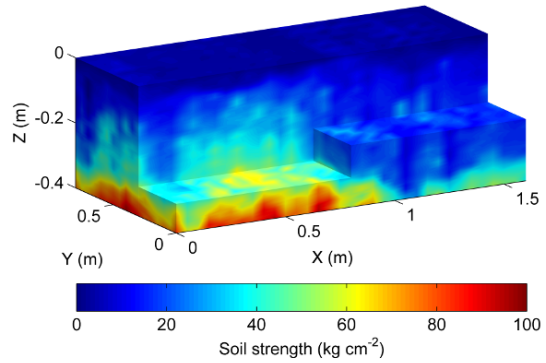
OBJECTIVES

(i) to develop a method for the assessment of physical quality of agricultural soils that takes into account the soil profile heterogeneity

(ii) to illustrate the method by evaluating the effect of different tillage practices and wheel traffic on SPQ.

METHOD

Penetration resistance (PR) measurements



Soil core sampling

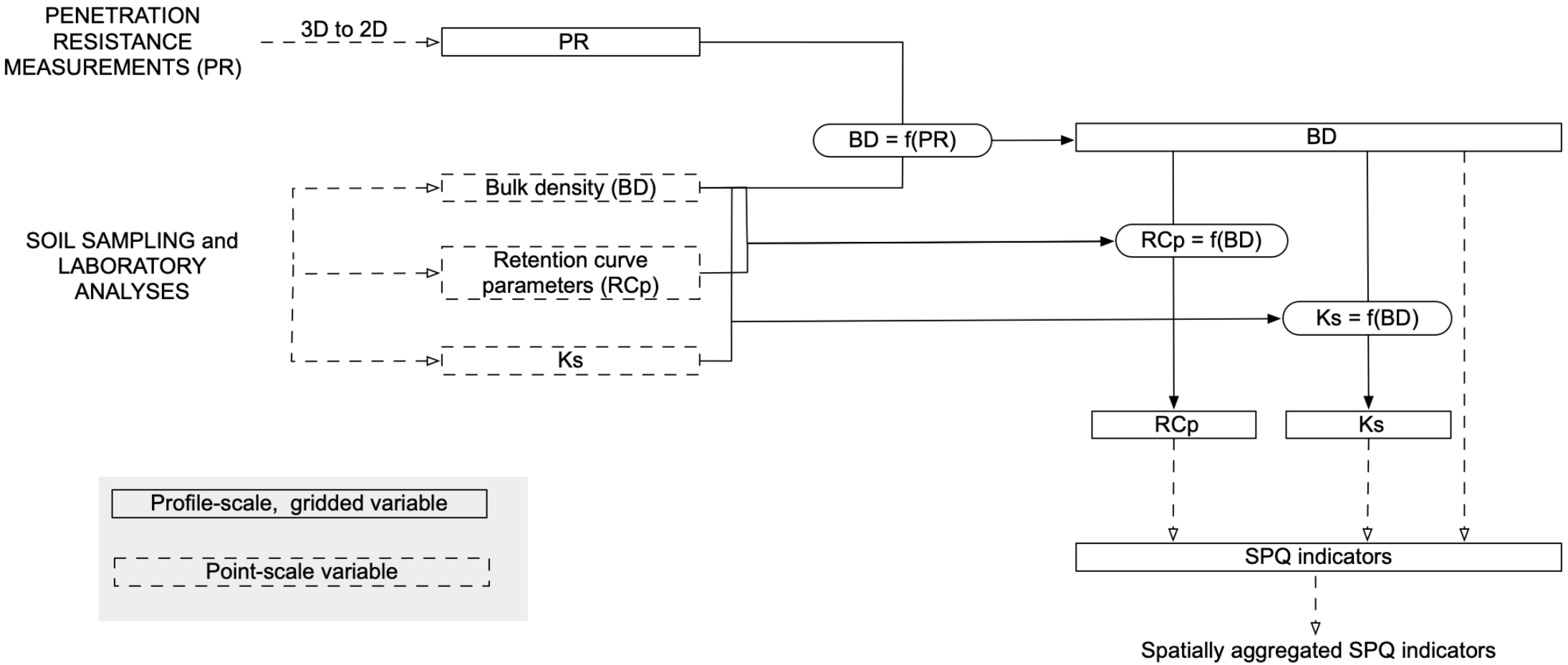
+ Standard laboratory analyses

Penetration resistance = f(Bulk Density)

Bulk density = f(hydrodynamic parameters)

METHOD

From point-scale to profile-scale



METHOD

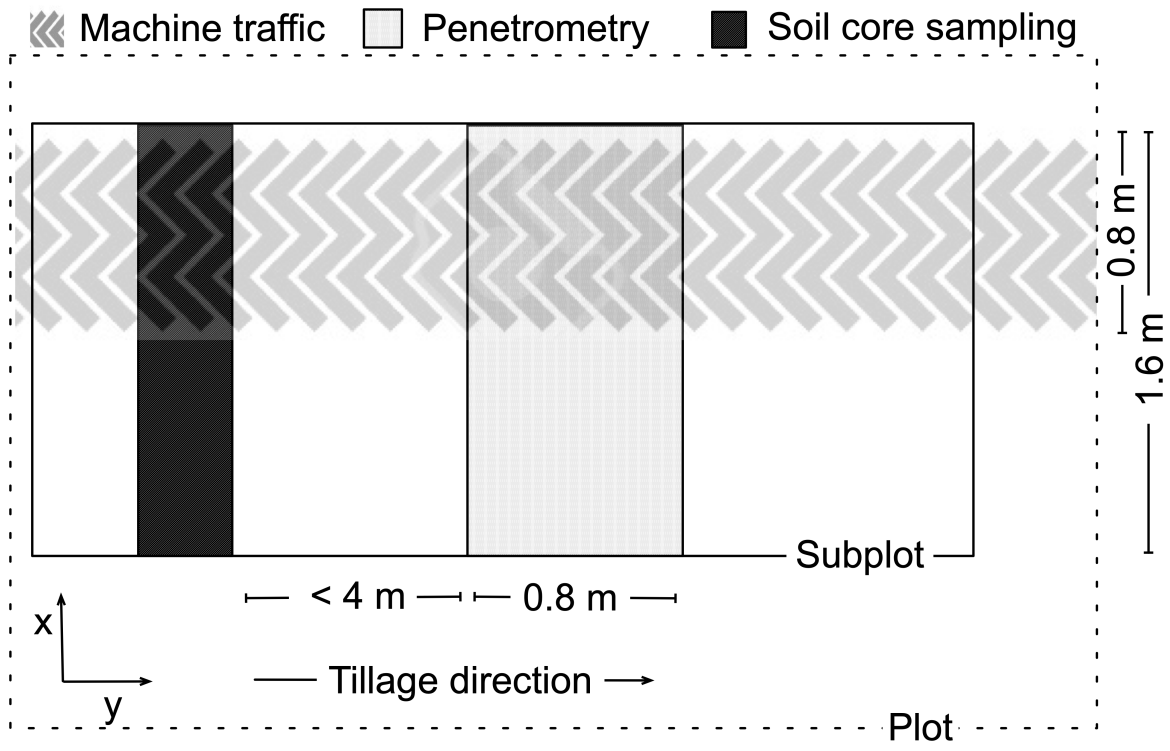
Indicators

Indicator, symbol and unit	Indicator definition	Soil physical quality property measured
Saturated hydraulic conductivity, Ks ($cm.s^{-1}$)		Ease with which pores of a saturated soil transmit water
Bulk density of total soil, BD ($g.cm^{-3}$)	Mass of dry soil solids per unit bulk soil volume	Index of soil strength. Also used to obtain the other indicators.
Porosity of soil macropore domain POR_p ($m^3.m^{-3}$)	POR_p = (h=0) - (h=-10cm)	Volume of soil pores with equivalent diameters ≥ 300 um (soil macropores) indicating the soil's ability to quickly drain excess water and facilitate root proliferation.
Porosity of soil macropore domain POR_p ($m^3.m^{-3}$)	AC_t = (h=0)- (h=-100cm)	Index of soil aeration on total soil volume basis
Porosity of soil macropore domain POR_p ($m^3.m^{-3}$)	PAWC = water content at field capacity (FC) - water content at permanent wilting point = (h=-100cm) - (h=-1.5 x 10^4 cm)	Soil water readily available for crop growth
Relative field capacity RFC (-)	RFC = FC / = (h=-100cm)/	Soil's ability to store water and air relative to the soil total pore volume
S-value	Slope of the soil water retention curve at the inflection point, calculated as:	Indicator of overall quality for crop growth
Homogeneity index I_h	Based on penetration resistance data. See Roisin (2006) for details.	Structural homogeneity of soil layer

METHOD

Experimental set-up

- ~ 18% clay, 75% loam, 7% sand
- Three tillage treatments
  - Moldboard plowing (MP)
  - Deep loosening (DL)
  - Minimum tillage (MT)
- Trafficked >< Untrafficked
- 3 repetitions per treatment
- 86 soil samples



METHOD

Soil physics lab at UCLouvain

Retention curve

- 2 sandboxes
- 6 pressure plate extractors
- 1 water potential analyser for high pF by psychrometry (WP4C).
- A 10-cell HYPROP system

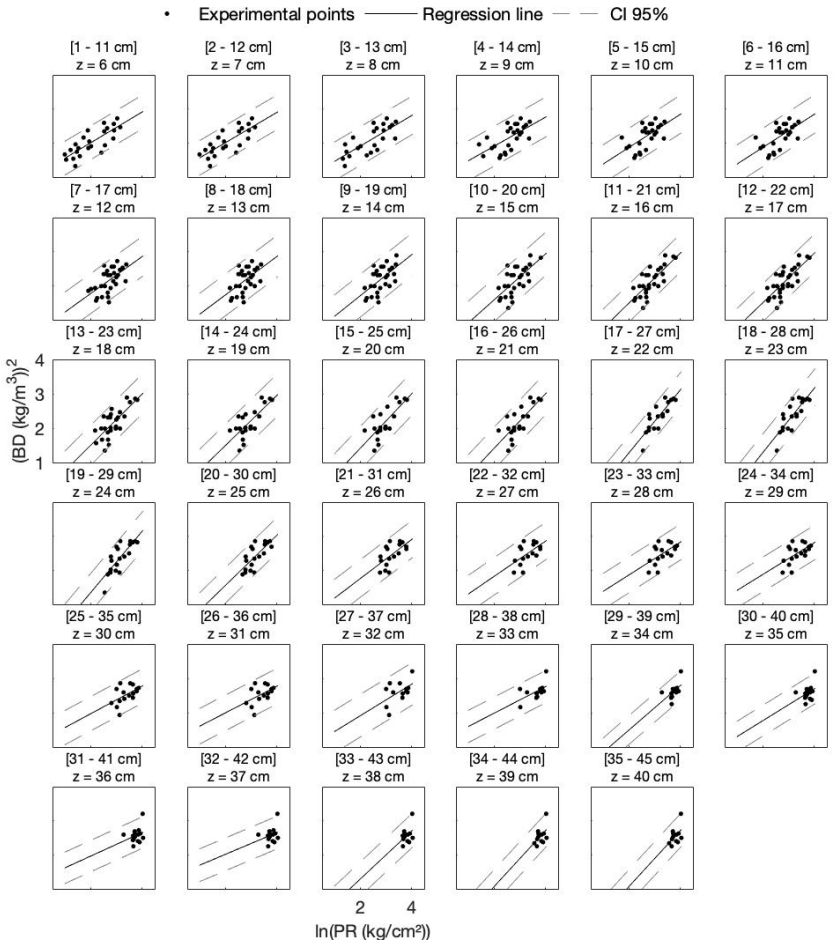
Hydraulic conductivity curve

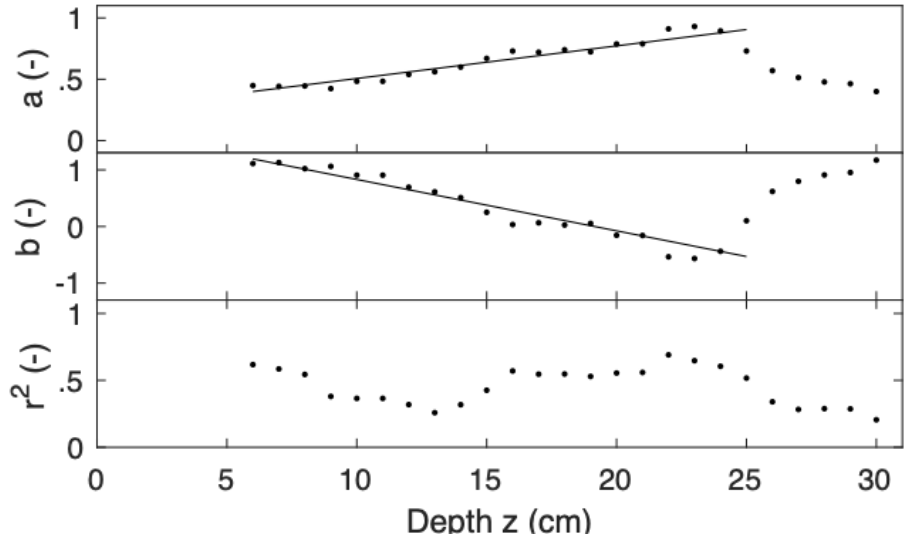
- Multistep Outflow
- a permeameter
- HYPROP system

RESULTS

PR - BD relationship

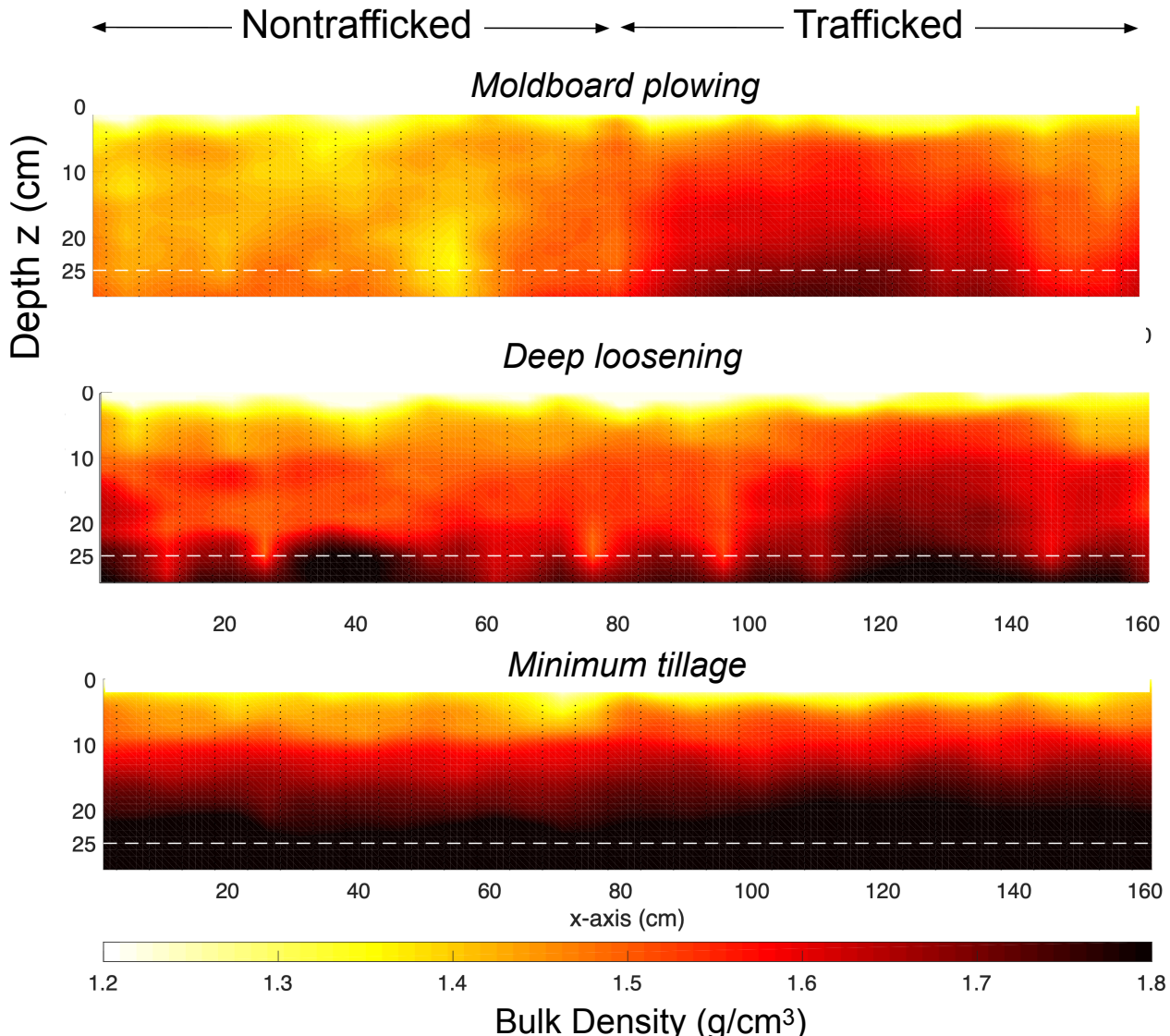
$$BD_{xz}^2 = a_z \ln(PR_{xz} + b_z)$$





RESULTS

PR - BD relationship

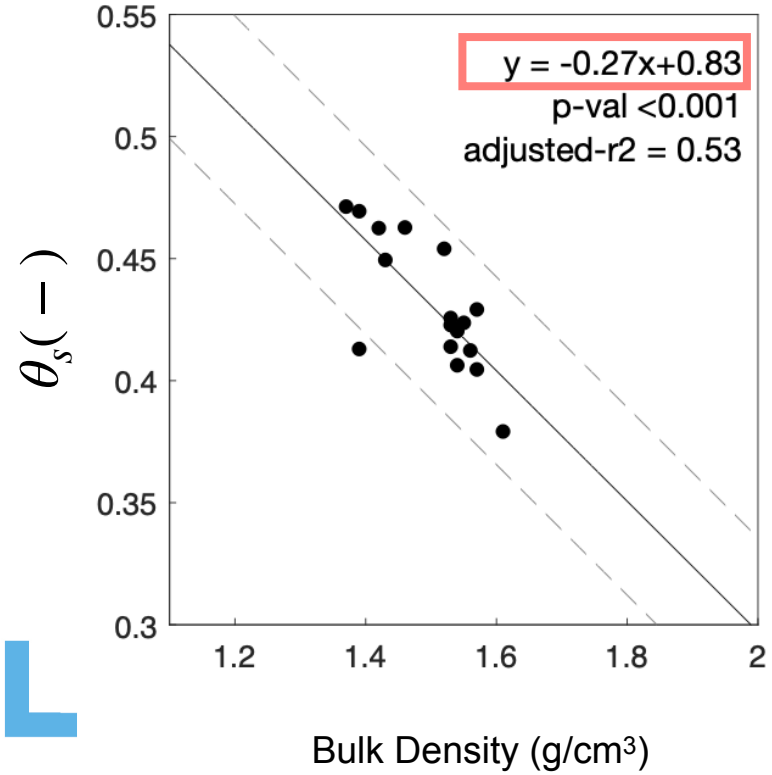


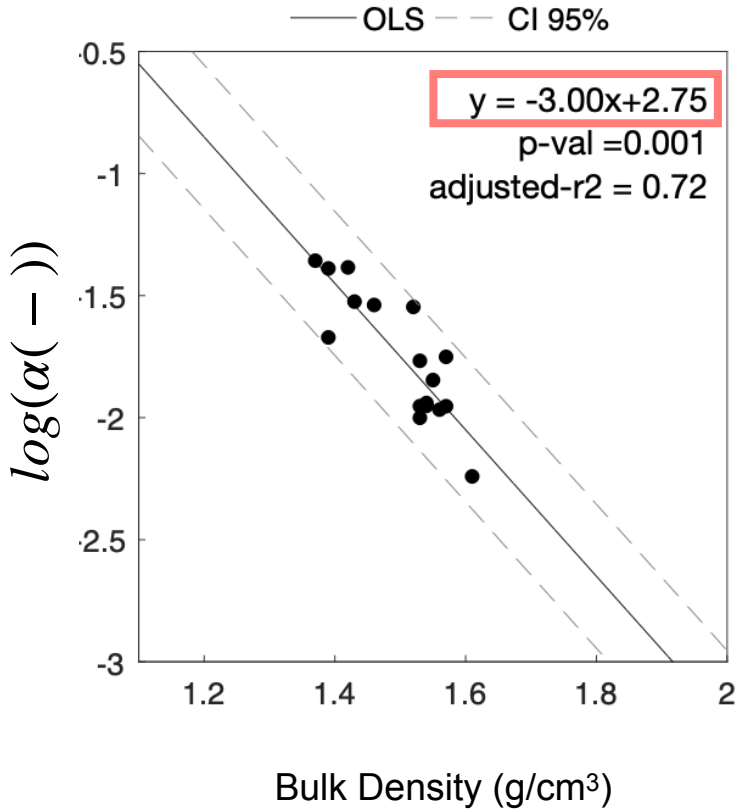
RESULTS

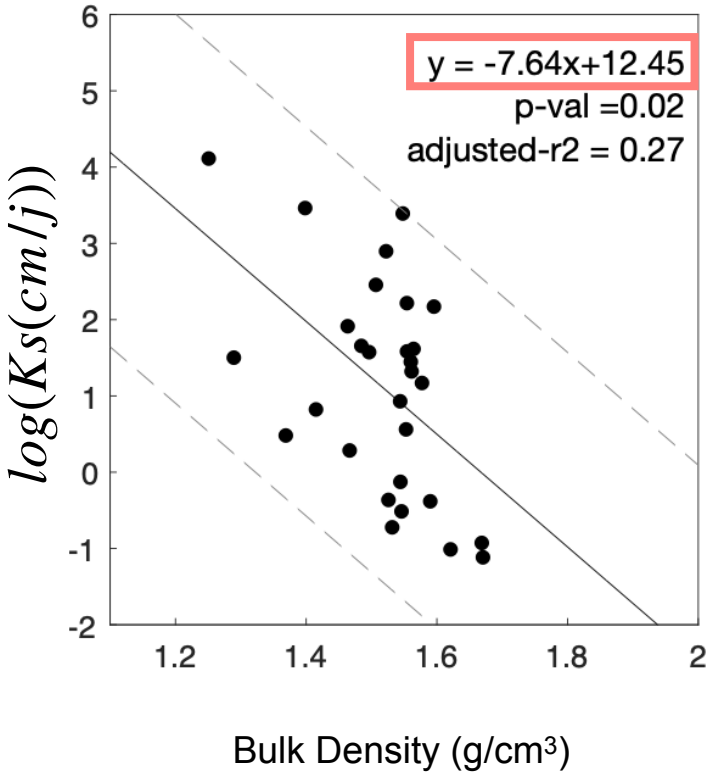
Relationships between BD and the hydrodynamic parameters

$$\theta_v(h) = \theta_{v,r} + \frac{\theta_{v,s} - \theta_{v,r}}{(1 + (\alpha lhl^n)^m}$$

$\theta_r = 0$
n = constant
M = 1-(1/n)

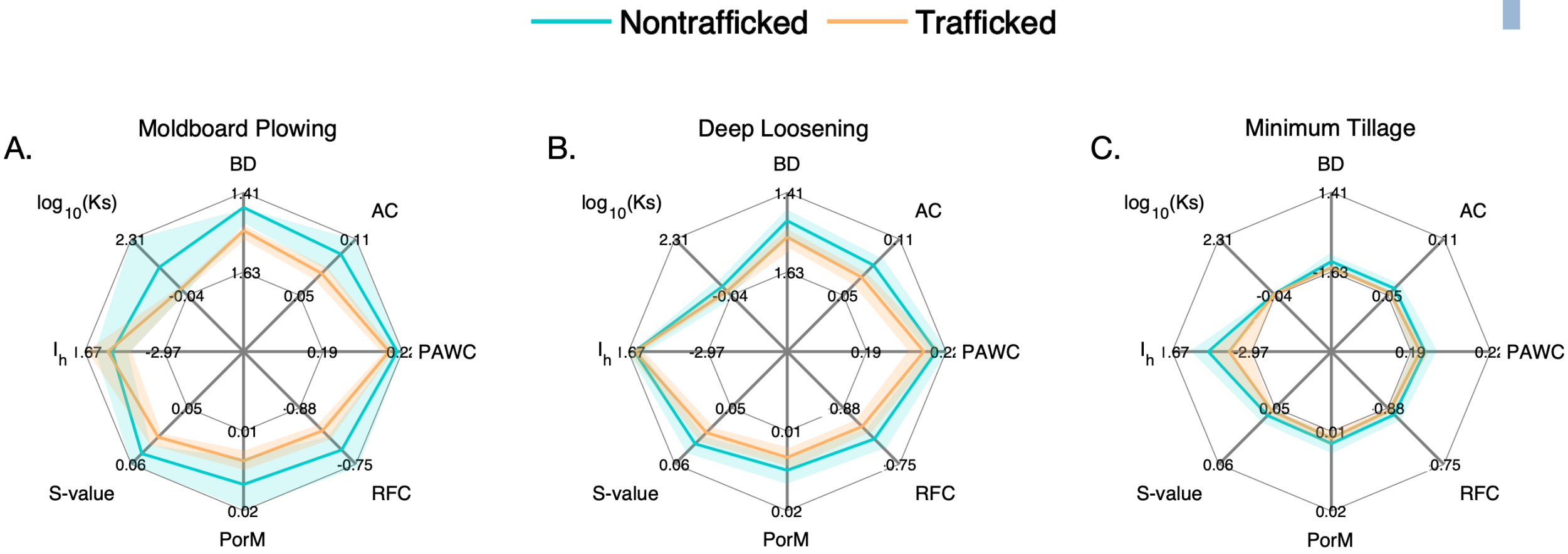






RESULTS

Assessment of the soil physical quality



Conclusions

- Method to assess the SPQ that captures the spatial heterogeneity
  - Highlight and compare the effects of vehicle traffic and tillage on the soil structure and the SPQ
  - ⚠ Soil health = soil physical + chemical + biological quality
  - ⚠ Soil health = f(soil functions and services)
- Resulting data useful for studying the impact of soil tillage and traffic-induced structural heterogeneity on soil hydrodynamics
  - Mechanistic assessment of soil functions
  - Improve the reliability of coupled land-atmosphere models

THANK YOU!

Charles Bielders, Manuel Froidevaux, Mathieu Javaux, Eric Laloy, Samuel Mattern, Christian Roisin, Marnik Vanclooster.

- Alonso et al. 2021. Hybrid method for characterizing soil physical quality at the profile scale with fine spatial details. Soil Tillage Res. 216, 105236 (2021).
- Alonso et al. Fine resolution profile-scale data to depict the impact of treatment and machine traffic on agricultural soil structure and hydrologic properties. Under review in Data In Brief.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