Pore structure characteristics and soil workability along a clay gradient

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Background and aim

- Clay is a basic soil constituent that governs many soil properties including pore characteristics, which in turn control a range of crucial soil properties and functions.
- Soil workability is an indicator of the ease with which the soil can be tilled to produce the desired soil fragments for crop establishment (Dexter, 1988; Goense, 1987).
- Quantitative information on influence of clay content and matric potential on soil workability very relevant for addressing cultivation problems in agricultural soils with clay variability.
- Our aim was to quantify effect of clay content on soil pore structure characteristics and soil workability for a soil with a naturally occurring clay gradient.

Materials

Soil samples from four locations with similar soil organic carbon content, but with a naturally occurring clay gradient from an arable field near Lerbjerg, Denmark. Clay content of sampled location are 0.119, 0.220, 0.289 and 0.446 kg kg⁻¹ for L12, L22, L29 and L45, respectively (Obour et al., 2019).

Results

Bulk density (ρ_b); volumetric water content (θ) at -100 hPa; water content at plastic limit (θ_{PL}); air-filled porosity (ϵ_a) at -100 , -300 and -1000 hPa; relative gas diffusivity (Dp/Do), tortuosity (τ), air permeability (k_a) and pore organization ($PO_f=k_a/\epsilon_a$) at -100 hPa.

	Soil			
	L12	L22	L29	L45
ρ_b (Mg m ⁻³)	1.41 (0.02)	1.43 (0.01)	1.37 (0.01)	1.22 (0.02)
θ (m m ⁻³), -100 hPa	0.27 (0.00)	0.39 (0.01)	0.43 (0.00)	0.49 (0.01)
θ_{PL} (kg kg ⁻¹)	0.21 (0.004)	0.23 (0.004)	0.25 (0.003)	0.29 (0.007)
ϵ_a (m m ⁻³), -100 hPa	0.20 (0.01)	0.07 (0.01)	0.06 (0.01)	0.05 (0.00)
ϵ_a (m m ⁻³), -300 hPa	0.25 (0.01)	0.11 (0.01)	0.10 (0.01)	0.09 (0.00)
ϵ_a (m m ⁻³), -1000 hPa	0.28 (0.01)	0.14 (0.01)	0.13 (0.01)	0.14 (0.01)
Dp/Do , -100 hPa	0.021 (0.00)	0.006 (0.00)	0.004 (0.00)	0.002 (0.00)
k_a (μm^2), -100 hPa	55.4 [0.24]	30.5 [0.66]	14.5 [0.66]	4.3 [0.79]
PO_f (μm^2), -100 hPa	282.7 [0.23]	438.6 [0.59]	259.2 [0.61]	85.7 [0.80]
τ (m m ⁻¹), -100 hPa	5.2 (0.33)	9.6 (1.70)	14.2 (2.40)	21.7 (5.15)

Numbers in parentheses are standard errors.
Numbers in square brackets indicate standard errors for the log-transformed data.

Friability (quantified as the slope of the plot of the natural logarithm of tensile strength for all size fractions and the natural logarithm of the aggregate volume) as a function of matric potential. Friability classification: <0.1 = not friable, $0.1-0.2$ = slightly friable, $0.2-0.5$ = friable, $0.5-0.8$ = very friable and >0.8 = mechanically unstable (Imhoff et al., 2002).

The range of water contents for tillage for L12, L22, L29 and L45. θ_{DTL} : dry tillage limit, θ_{OPT} : optimum water content for tillage and θ_{WTL} : wet tillage limit estimated using the “consistency approach” (Obour et al., 2018). Solid short vertical lines show water contents at -100 hPa matric potential. Matric potential (hPa) at θ_{WTL} and at θ_{DTL} are shown.

Conclusions and Implications

Average yearly workability during the spring and autumn over 2014 to 2018 for the investigated soil. Workability limits estimated using the “consistency approach” (Obour et al., 2018). Numbers in parenthesis show the range of workable days.

Soil	Workable days in spring	Workable days in autumn
L12	35 (69)	37 (22)
L22	47 (66)	34 (23)
L29	32 (46)	24 (14)
L45	0 (1)	0 (0)

- The average workable days in the spring and the autumn generally decreased with increasing clay content.
- A uniform tillage operations of a texturally variable field might not be the best management option unless operations are properly scheduled.
- Proper planning and performing tillage operations based on site-specific soil workability is a prerequisite for improving soil fragmentation in tillage and for optimizing resource utilization to reduce the risk of soil structural damage from tillage.
- Overall findings of this study imply that management practices that increase soil macroporosity can potentially decrease aggregate strength and increase the range of water contents for tillage to improve soil workability, which in turn can reduce cultivation problems in agricultural soils with a wide range in clay contents.