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Effects of grassland on bulk density of soil and mechanical resistance

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Bulk density and mechanical resistance measured at core scale are good indicators of soil structure quality. Mechanical resistance is described by the compression characteristics that show the relationship between stress applied on a soil sample and a volumetric parameter such as void ratio e_0. Compression curves define: (i) the pre-compression stress P_c (ii) the slope of the virgin compression line VCL, namely compression index C_c. Those two parameters depend on soil properties, which are influenced by practices such as tilled or no-tilled systems. However, the effect of grasslands in mechanical resistance remains to be clarified.

In this study, we evaluated the effect of the duration of grasslands on bulk density and mechanical properties of soils. Soils originated from a long-term experimental site: Yvetot (France), where till, permanent and temporal grasslands are compared. We selected there four systems: tilled and permanent grassland as reference systems and two temporal grasslands, which began in 1994 and 2000 respectively. For each system two large undisturbed monoliths were sampled in the 0-20 cm horizon in March 2003, so that the duration τ of temporal grasslands are 9 and 3 years respectively. Five small cylindrical cores, 5 cm diameter and 2 cm height, of undisturbed soil were made from each larger monolith. The water content was adjusted, just before mechanical test, to a matric potential pF of 2.5. Uniaxial compression curves were measured using a hydraulic oedometer apparatus in drained conditions by applying successive total vertical stresses (from 1 to 1500 kPa). Mechanical parameters were calculated with the Gompertz's model fit applied to S-shaped curves. C_c parameter was the tangent, in absolute terms, to the compression curve at inflexion point. In bi-linear model, the VCL was established by linear regression of compression curves, in logarithmic scale, above an external stress of 100 k Pa. In both cases, the P_c value was the intercept of VCL with a horizontal line taken at e_0. The bulk density was the most affected variable in the set of grasslands. In the tilled reference system, the mean value of e_0 was low (0.9 ± 0.15) and continuously increased with the duration τ up to 1.6 ± 0.27 for permanent grassland. In the tilled system, the global shape of the compression curves obeyed to an S-shape model, except for the lowest values of e_0 (below 0.75), where bi-linear curves yielded a better fit. The global shape of compression curves is affected by grassland, where bi-linear curves are obtained in an unexpected way for such high values of e_0. This fact reveals the strong change in internal soil structure and in water soil interaction. However neither the P_c values nor their variability were affected by a grassland effect (P_c = 41 kPa $\pm$ 9). A temporary decrease was only registered at τ=3 years (P_c = 33 kPa $\pm$10). The value of the compression index linearly increased with e_0 in every case. The low value of the slope revealed the anisotropy of soil samples probably due to the set of roots. To conclude, those results highlighted the positive impact of grassland on soil structure and their crucial role on soil mechanical properties.

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