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Impact of soil water repellency on mechanical resistance

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The long term experiment in Versailles began in 1929 with the aim of determining the impact of mineral fertilisation on changes with time of the physico-chemical properties of a loamy soil. Nowadays the first noticeable result is the impact on soil pH that varies from very acid (3.5) to alkaline (8.2) depending on the fertilizer or amendment type. Such a variation in pH had consequences on wettability both of soil and its clay fraction. The most acid soil had the lower wettability (according to the capillary rise method and the determination of the angle of contact in clay fractions). The second result was the impact of fertilization on soil structure. The crust development was faster in acid soils, leading to a decrease in infiltrability and favouring erosion. Up to now, the impact of fertilization on mechanical resistance has not been thoroughly studied. The aim of this paper is to investigate the impact of fertilizers on soil stability by combining aggregate stability and mechanical resistance at the core scale. In particular, this was done taking into account the effect of pH, whereas it influences the hydrophobic/hydrophilic balance, crucial to soil/water/air interaction and soil structure. Six plots of similar texture and bulk density were chosen, with pH ranging from 3.5 to 8.2. Compression curves were obtained in drained conditions using unstructured soil samples of equal density in saturated and unsaturated conditions. The precompression stress Pc and compression index Cc were then derived. The shape of the compression curves varies with the pH: highly acid plots have round curves, acid plots bi-linear ones, and from low acid to alkaline, S-shape curves are obtained. At the same time, the deformation rate decreased when the pH dropped. Acid soils reached an equilibrium state more quickly than other soils. Whereas a compression loading time of 15 min was appropriate for acid soils, a longer loading time (e.g. 30 min) was required for alkaline soils. The Pc values of highly acid soils were greater than 150 kPa, whereas other plots had Pc values of about 20 kPa. Highly acid soils appeared more mechanically stable than others but their Pc values decreased down to 40 kPa when they were air-dried before the compression tests. Aggregate stability tests revealed the unstable feature of all plots and especially in the case of the highly acid plot, a narrow distribution of fragments among <50μm particles was found in both solvents: water and ethanol. Those results suggest an homogeneous distribution of hydrophobicity in soil cores and a narrow pore size distribution, which was confirmed by the reproducibility in water content at this scale at pF 2.5. The complementarity of both scales studied, aggregate (1 cm3) and core scale (100 cm3), suggests that the limited compression of highly acid plots is due both: to a water trapping process and to water incompressibility. Ammonium and phosphate ions contained in the soil water solution might be involved with the soil pH in this phenomenon. Structured soil samples have to be used to fully understand the combined effect of pH and fertilisers on soil stability.
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