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AN AGRICULTURAL SOIL BETWEEN TILLAGE AND PASTURE

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Abstract. Le but de cette publication est de souligner l'évolution au niveau morfo-micromorphologique d'un sol influencé par le changement répète de l'utilisation du terrain (pâturage – arable - pâturage). Le site étudié est situé dans la Dépression d'Oltenia, dans la région de Botorogi où le climat est continental tempéré, la température annuelle moyenne est de 10,2°C, tandis que la précipitation annuelle moyenne est de 914,7 mm. Le drainage naturel global est imparfait. La nappe phréatique a une profondeur de 2,5 à 3 m. Le sol est Eutricambosol gleic aluvic (drainé) (selon SRTS-2012 et Fluvic Endogleic Cambisol Eutric - selon WRB-SR-2014) formé dans des dépôts alluviaux avec texture limon argileux. Le profil du sol est situé sur un terrain qui a changé son utilisation plusieurs fois: du pâturage (de nombreuses années) en arable (quatre ans) et de terre arable on changé à nouveau dans le pâturage (actuellement). Les données corroborées (morphologiques, analytiques, micromorphologiques) conduisent à la conclusion que la compaction de l'horizon Ao₂(t) est causé par le passage fréquent de la charrue à la même profondeur, étant similaire à la „semelle de labour”. Après le changement répété de l'utilisation du terrain, la principale caractéristique d'un sol agricole (l'horizon labouré compactée Apt) restent résiduel dans le sol de pâturage, représenté par l'horizon Ao₂(t). Après quelques années de pâturage et dans les conditions d'une activité biologique relativement élevée, l'état structural du sol n'a pas été reconstruit, nécessitant plusieurs années pour le restaurer. Le suffixe „(t)” qui dérive de „couche de compaction causé par le labour” a été proposé pour marquer la présence d'une „semelle de labour” résiduel, dans le sol actuellement sous pâturage

Keywords: agricultural soils, pasture, micromorphology, tillage

1. Introduction

Land use and vegetation respectively, lead the genesis of the pedogenetic horizons, so that soils developed in the ecosystems with different land use have specific pedogenetic horizons.

Răducu (2015) showed that soils from different ecosystems are characterized by one or more specific horizons which distinguish them from all other soils. As for example: the soils under the forest (irrespective of their type or subtype) have an organic O horizon, as well as the soils beneath the meadows or pastures have an A₁ horizon. In this respect, the soils from the arable land have in the upper part a layer affected by tillage, consisting of two horizons: Ap (ploughed) and Apt (ploughed compacted).

Into the Apt horizon of tilled plots it can be also noticed a strong reduction of regular and irregular pores, with respect to the upper Ap horizon; since these pores were mainly

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originated in the burrows of soil fauna, their decrease could be ascribed to a collapse due to compaction (Răducu et al., 2002).

Enhanced dynamics between soil biota, especially earthworms, carbon inputs and soil aggregation contributed to higher direct surface water infiltration when compared to conventional practices; whereas tillage prevented earthworm proliferation and topsoil organic carbon accumulation (Castellanos-Navarrete et al., 2012).

Larger organisms in general appear to be more sensitive to tillage operations than smaller organisms, due to the physical disruption of the soil, burial of crop residue, and the change in soil water and temperature resulting from residue incorporation (Kladivko, 2001).

Land use change and intensification in agricultural landscapes have resulted in widespread soil degradation and a loss in soil-based ecosystem services and biodiversity; this trend threatens the sustainability of farming communities with important implications for food security and biodiversity conservation (Valenca et al., 2017).

Soil degradation, characterized by decline in quality and decrease in ecosystem goods and services, is a major constraint to achieving the required increase in agricultural production (Lal, 2015).

Land use change derived by human activities is considered the most important factor for biodiversity losses, and a large number of studies have documented the negative effects of land use change for plants, animals and most recently microorganisms (Navarrete et al., 2016).

The aim of the paper is to emphasize the evolution at morpho-micromorphological level of a soil influenced by the repeated changing of the land use (pasture – arable – pasture).

2. Material and methods

The investigated site is located in Oltenia Depression, in the Botorogi region where the climate is temperate continental, and the bioclimate is deciduous forest (oak forests). The average annual temperature is of 10.2°C, while the average annual rainfall is 914.7 mm. The global natural drainage is imperfect. The water table is at 2.5 - 3 m depth. The soil is Eutricambosol gleic aluvic (drained) (according to SRTS-2012; and Fluvic Endogleic Cambisol Eutric – according to WRB-SR-2014) formed in fluvic clayey-loam deposits.

The soil was sampled (disturbed for physical and chemical analysis; and undisturbed for the micromorphological study) and analyzed according to the standard methods of ICPA-Bucharest (ICPA Methodology-1987). The micromorphological undisturbed samples were air dried and impregnated with epoxidic resins. After hardening, oriented thin sections (25 - 30 µm) have been made from each sample and studied with Documator (20 X) and optical microscope (50-100 X) in PPL (plain polarized light) and XPL (cross polarized light). The terminology used for micromorphological description was according to Bullock et al. (1985).

3. Results and discussions

The studied site is located on a land that repeated change the land use: from pasture (many years) to arable (four years), and from arable back to pasture (at present).

The morphological characteristics of the studied soil revealed, during the expeditionary field observations, important characteristics of the structure and poral system (comparing to a classic soil formed under pasture).

At the soil surface an A_t (0-8 cm) horizon consisting of root felt (re-)appear during the last years of pasture land use. The terrous material between the roots was clayey. The structure determined in the field (at the soil water state: dry-moist) is fine and very fine granular. Common coprolites are present, among the vegetal remains. The lower boundary of the horizon is abrupt, smooth.

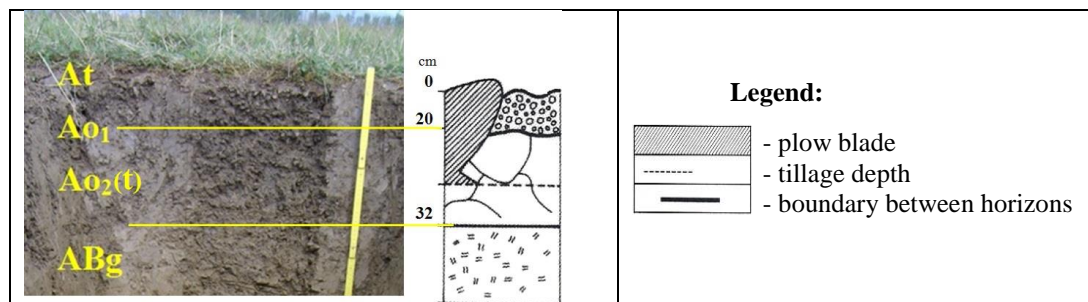


Figure 1. The pedogenetic horizons corresponding to the „tilled layer“ and the sketch with the ploughed depth

The A_{o1} (8-20 cm) horizon (formed below the A_t) had clayey texture and the structure (determined in the field at the soil water state: dry-moist) was medium – fine subangular blocky (still bearing the influence of tillage, prior to the meadow land use). The soil is moderately compact and extremely firm when moist, but very hard when dries. In what concerning the porosity, it consists of many fine pores. Medium earthworm channels (many of them with coprolites) also appear in the horizon. Fine roots were common, while the medium ones were few. The boundary to the next horizon was clear, smooth.

The A_{o2(t)} (20-32 cm) horizon had clayey texture. The structure was medium – coarse angular blocky (determined at the soil water state: moist) and the horizon is very compact (strongly bearing the influence of tillage, prior to the meadow land use). The soil is extremely firm when moist, and very hard when dries. The porosity consists of common fine pores. Soil biological activity was highlighted by the presence of medium channels and common medium coprolites created by soil fauna. Fine roots were few. The lower boundary of the horizon was abrupt, smooth.

The AB_g horizon (32-50 cm) was silty clay and had medium angular blocky structure (determined in the field at the soil water state: wet). The horizon is medium compact, and extremely firm when moist, but very hard when dries. Porosity consists of common fine pores. The biological activity was highlighted, as in the upper horizon, by the presence of common medium channels and coprolites (created by soil fauna). Fine roots were few. In this horizon redoximorphic features (as Fe±Mn oxihydroxides mottles) were observed.

The analytical data showed that soil granulometry was clayey in the upper part of the soil profile, the clayey fraction being dominant (Figure 2), with values ranging from 46.7% in the compacted horizon (A_{o2(t)}) to 51.2 - 51.4% in the two surface horizons (A_t and A_{o1} respectively).

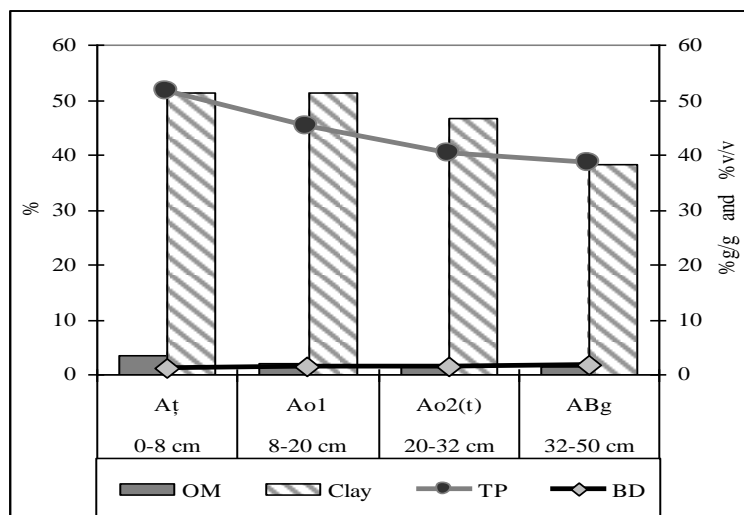


Figure 2. Physico-chemical characteristics of the studied soil

On the general background of this clayey profile, the bulk density (Figure 2) is medium (1.28% g/g) in the top Aḡ, and big (1.46% g/g) in the underlined Ao₁ horizon. Into the compacted Ao₂(t) horizon, the value of the bulk density increased to very high (1.58% g/g).

The total porosity (Figure 2) is very small - medium, the highest value being recorded in the surface horizon (due to common biological porosity created by the roots). This value decreased slightly (at 45.1% v/v) in Ao₁ horizon and drastically (at 40.4% v/v) in the more compacted Ao₂(t). The values of the bulk density and the total porosity pointed out that the Aḡ horizon is slightly compacted, the Ao₁ is moderately compacted, while the Ao₂(t) horizon is highly compacted.

Correlating all these analytical data with the soil organic matter content (Figure 2), it can be underlined that humus is relatively low (for a soil under pasture). This could be, probably, a consequence of the grubbing up the pasture for cultivation, as well as of the short time of post-agricultural reinstatement of pasture vegetation. Under these conditions, the organic matter content is low (3.36%) in the A horizon and drastically decreases to 1.98 and 1.74 respectively in Ao₁ and Ao₂(t) horizon respectively.

The micromorphological study (by the aim of the optical microscope) showed that the soil was formed in un-uniform parental material, according to the quality, quantity and the size of the skeleton grains that differ widely between the pedogenetic horizons. In Ao₂(t) horizon the skeleton grains becomes very abundant compared to the upper Aḡ and Ao₁ horizons, and still remains to a high level up to Bv₂Go (80-100 cm) where the amount and the size of the skeleton grains strongly decreased.

The soil matrix is dominated by the clayey plasma component that formed stipple-speckled b-fabric, strongly birefringent, emphasizing clay orientation during fluvio-lacustrine deposition. Biological activity is very intense in the surface horizons (Aḡ and Ao), where the biological pedofeatures are very abundant, generated by the activity of phyto-, terro- and coprofaun soil fauna.

It is worth mentioning that although under the pasture and with a relatively high biogenic activity, in the soil profile there is no bioturbation. This could be due to the moisture excess in the lower part of the soil profile (50 – 165 cm) that hinder the vertical movement of the soil fauna.

This moisture excess favored periodic waterlogging and anaerobic conditions, and generated redoximorphic features (slightly different in terms of extension and localization) starting with the horizon ABg (Figure 3) and ending with the CnGr horizon (120 -165 cm - Figure 4), giving them a mottled appearance.

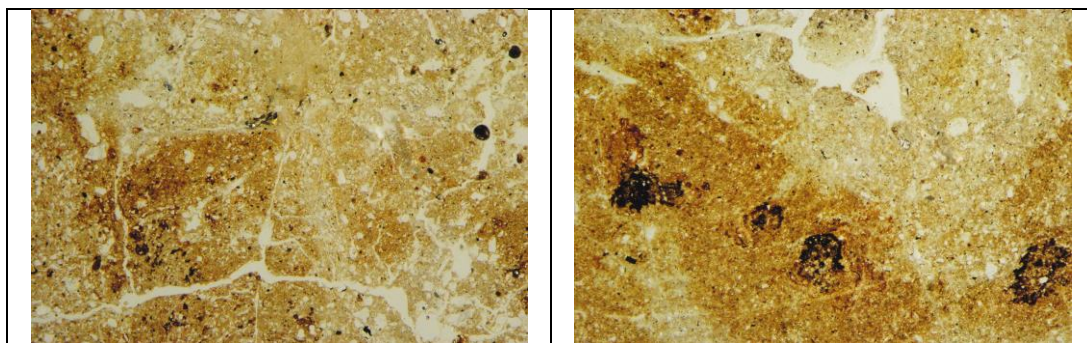


Figure 3. ABg (32-50 cm) horizon: ferruginous±Mn mottles surrounded by zones depleted of Fe±Mn

Figure 4. Bv₂Go (80-100 cm) horizon: zones depleted of Fe±Mn in the pore walls; ferruginous±Mn mottles inside the matrix

The amorphous pedofeatures (as ferruginous±Mn mottles) appear surrounded by the depletion pedofeatures (zones depleted of Fe±Mn) in ABg horizon (Figure 3). In the CnGr horizon, the amorphous pedofeatures are clearly located (Figure 4): the zones depleted of Fe±Mn were formed in the pore walls, while the ferruginous±Mn mottles (also containing aggregate nodules) formed inside the soil matrix.

In what concerning the micromorphological features as reminiscence of tillage during the arable land use, in the Ao₂(t) horizon, the close porosity (represented by simple packing voids), as well as vughy structure (generated by the collapsed of the biogenic pedofeatures) were observed. In these conditions, the type and the evolution of the Ao₂(t) horizon should be understand throughout the tillage influence.

Thus, the shape and the size, as well as the 3-D arrangement of the structural elements and the adjacent pores, depends on the agricultural tools geometry and the ped kinetic during tillage. The spatial arrangement (loosed or stuffed) of the aggregates are closely dependent on their kinetic received from the agricultural tools during tillage. The main mechanism of soil compaction (in this horizon) is due to the plowing at the same depth and to the well pressure (both on soil surface and into the furrow) during the short time of the land use as arable.

Even if the soil was few years under pasture and consequently the compacted Ao₂(t) horizon under the influence of many restoring processes (fragmentation during wetting-drying as well as during freezing-thawing; structuring under biological activity etc.) the structural state of the soil was not improved, its restoration requiring a longer period of time.

In the conditions of a remnant tilled layer in the pasture soil, there is no possibility of marking it in the morphological description. In the soil classification (SRTS-2012): there is

neither a „prefix“, nor a „suffix“ for this remnant layer. Thus, in the paper it is proposed the suffix „(t)“ from „compacted under tillage“ (*tasat* - in Romanian), as it is used for the Apt horizon formed in the agricultural soils. The suffix was already used for the more compacted A₀₂ horizon (A₀₂(t)).

Conclusions

The following **conclusions** can be drawn:

- The corroborated (morphological, analytical, micromorphological) data lead to the conclusion that the compaction of the A₀₂(t) horizon was due to tillage.
- After the repeated changing of the land use (pasture – arable – pasture) the main characteristics of an agricultural soil (the compacted Apt horizon) persist in the pasture soil as a remnant tilled feature (A₀₂(t) horizon).
- After few years of pasture and under the conditions of a relatively high biological activity, the structural state of the soil was not reconstructed, requiring a longer period of time to restore.
- The suffix „(t)“ from „compacted under tillage“ was proposed to marked the presence of a remnant tilled layer, in the soil under pasture.

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