THE BEHAVIOUR OF A SOIL CONDITIONER IN SOIL

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Abstract

Structural conditioners are used in agriculture to prevent crust formation. Less works deal with the distribution of conditioners in soil. The paper emphasized, by the aim of micromorphological study on soil thin sections, the distribution of a conditioner (Ponilit GT-1) into the soil.

For better observation and understanding of the conditioner behavior in soil, an experiment has been established in the laboratory: undisturbed soil from the upper part of a Chernozem (susceptible to crust formation) has been sampled, brought in laboratory and treated with Ponilit GT-1. For a good visualization of the Ponilit GT-1 into the thin sections, it has been stained using two dyes: hematoxylin (red) and methylene (blue).

The results of the micromorphological study pointed out the distribution of the conditioner as: thin films on the surfaces of soil aggregates and on the walls of intrapedal voids, as well as bridges between aggregates (into the interpedal voids). Ponilit GT-1 formed two types of bridges: 1) thin, similar to those observed by De Bood (1990) which has been also called „strings" bridges and 2) thicker, which has been called „meniscus-like" bridges. The formation of the films (which coated aggregates or intrapedal voids) and of the bridges (which bind together either soil particles or aggregates), the studied conditioner contributes to the strengthening of soil architecture and to the maintenance of the favorable aerohydric conditions for a good biochemical activity in soil.

Key words: micromorphology, structural conditioner, polyelectrolyte, surface crust

INTRODUCTION

Structural conditioners (water soluble polymers, especially polyelectrolytes) are used in agriculture to improve soil structure, by its ability to stabilize structural aggregates and stop crust formation, inducing crops uniformity and, consequently, increasing the yields.

To prevent crust formation it was necessary to find a method to protect the soil surface during the periods without vegetation, an easy, efficient and inexpensive method to apply at large scale. The application of structural conditioners was the method that best suits these requirements and provides soil structure stabilization.

De Boodt (1989) showed that simple chemical soil conditioning is sufficient only when the physical properties of the soil are good and there is a balance of air and water in the rhizosphere.

Emerson (cited by De Boodt, 1989) made a model concerning the stabilizing effect of the soil conditioners, based on the idea that their effect is similar to that of the organic matter and sesquioxides.

Structural conditioner characteristics have been the subject of many theoretical and experimental studies, which emphasized that their positive effect is controlled by two characteristics: 1) the ability to rapidly penetrate into the soil pores, and 2) the capability to be adsorbed on clay edges or surfaces to promote inter-particle linkages (De Bood, 1990).

Studying a sandy soil with SEM, De Bood (1989) showed that the ionic conditioner has linked the sand particles by "strings" of polymer. In this case, the un-charged surfaces of the quartz grains (of the sandy soil) have been activated by treatment with the polyvalent metal ions (such as Fe^{3+}).

The soil conditioners are also used in the Romanian agriculture, thus, the laboratory and field researchers with Ponilit GT-1 (concerning its influence on crust formation) have already obtained favorable results (Chivulete et al., 1991; Răducu et al., 1994).

The purpose of this paper is to emphasize the behavior in soil of a structural condition (Ponilit GT-1), by the aim of micromorphological analysis. For an appropriate study in soil thin sections, a new technique, of marking the Ponilit GT-1 with dyes, was used.

MATERIAL AND METHOD

To visualize and understand better the distribution of a structural conditioner in soil, an experiment has been conducted in the laboratory in the year 2012: undisturbed soil from the upper part of a Chernozem (susceptible to crust formation) has been sampled, brought in laboratory and treated with Ponilit GT-1.

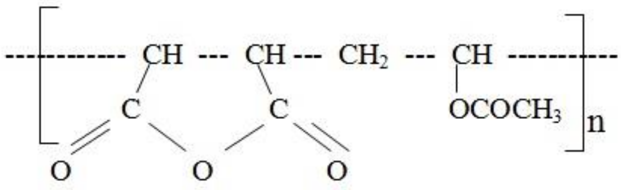
The soil material used in the experiment was collected from the upper horizon (Ap) of a Chernozem (Cernoziom Argic, SRTS-2012; Luvic Chernozem, WRB-SR - 2006) formed in loess-like deposits, with a clayey loam texture. The physical and chemical characteristics of the soil are presented in Table 1.

Table 1

The physical and chemical characteristics of the soil material used in the experiences (originated in the Ap horizon of a Chernozem)

Horizon/ Depth	**Sand**		**Loam**	**Clay**	**Organic matter**	**pH**	**BS**	**CEC**	**V**
	coarse	**fine**							
	2-0,2 mm	0,2-0,02 mm	0,02-0,002 mm	<0,002 mm	C x 1,72	in H_2O			
cm	**%g/g**					-	meq/100 g sol		**%**
0-18	0,0	31,3	30,8	37,9	2,32	6,3	8,46	12,2	69,6

The structural conditioner (polyelectrolyte) Ponilit GT-1, used in the experiment, has been obtained from a maleic anhydride alt-vinyl acetate (MA-alt-VA) copolymer synthesized by radical co-polymerization in benzene (Carpov et al., 1979), with the chemical formula:



The chemical composition and the viscometric molecular weight of the copolymer (measured according to Chitanu et al., 1993) were: the ratio MA:VA = 1:1 (molecular weight) is 98000 daltons, corresponding to a polymerization degree n of 540; the viscosity of the aqueous solution is 400 - 800 cP at 20^{o}C and c is 20 - 25%; the pH values ranging from 6,5 - 8.

Due to its yellowish brown color, which could be confused with soil matrix components, the Ponilit GT-1 was stained with 2 types of dyes:

- hematoxylin - red.
- methylene - blue.

The soil was collected undisturbed (to preserve the natural structure of the upper layer) in 7 micromorphological boxes (of 7cm/7cm /10cm), used as:

- 1 control, wetted with 50 ml of aqua, and
- 6 treatments (repetitions) from which:
  - 3 wetted with 50 ml of an aqueous solution of Ponilit GT-1 stained with hematoxylin.
  - 3 wetted with 50 ml of an aqueous solution of Ponilit GT-1 stained with methylene blue.

For the micromorphological analysis, after treatment, either the control or the treatments were air-dried (in the laboratory) and impregnated with polyester resins. From each hardened sample, an oriented thin sections (20μm/6cm/9cm) were fabricated and after words studied with stereomicroscope (6X), Documator Karl Zeiss Jena DL 5.1 (20 X) and optical microscope (50-500 X) in PPL and XPL. Bullock et al. (1985) terminology has been used.

RESULTS AND DISSCUSIONS

The results showed that in the control sample, a structural crust was formed, due to the disintegration of soil aggregates as a result of wetting.

With regards to the treated soil samples, under the protection of the structural conditioner (Ponilit GT-1) applied, no crust was observed.

The micromorphological analysis on the thin sections allowed the study of the polyelectrolyte distribution, down the soil material. No significant differences between the six repetitions have been observed.

In all the treatments, the soil structure was complex, with many interpedal, interconnected voids, which favor the accessibility of the polyelectrolyte into the voids.

The penetration of the polyelectrolyte into the interpedal voids, depend on their size and on the conformation of the polyelectrolyte macromolecules.

The maleic polyelectrolyte used in the experiment penetrates into a wide range of interpedal voids, different in size (from 30 to 200 μm Ø) and shape (circular, irregular, planar) and forms thin films (≤ 25 μm), which protect their walls (Fig. 1 and 2). The discontinuity of the thin films appears in the vicinity of the depleted mineral grains.

The conditioner had been quickly adsorbed on the surface of the soil aggregates as the solution infiltrates towards the sample, forming thin (< 5 μm), discontinuous films on ped surfaces (Fig. 1a and 2a). The continuity or the discontinuity of the polyelectrolyte films depends on the adsorption capacity of the soil components located in the aggregate walls (clay, organic matter, coated mineral grains, etc.). Once adsorbed a segment of polyelectrolyte macromolecule by soil components, further segments will adhere to the same or to the adjacent component (De Boodt, 1990). The degree of coverage of soil particles by the conditioner films is very important for the effectiveness of treatment.

Into the intrapedal voids (within aggregates), the Ponilit GT-1 formed thin films on their walls, promoting a good circulation of air and soil solution.

Into the interpedal voids (between the aggregates), the stained polyelectrolyte formed bridges which bind together soil aggregates (Fig. 1 and 2). The polyelectrolyte does not clog up the voids, not even the 30 μm ones.

The microscopic observations pointed out that Ponilit GT-1 formed two types of bridges into the interpedal voids:

- thin, similar to those observed by De Boodt (1990) which have been also called "strings" bridges (Fig. 1b) and
- thicker, which have been called "meniscus-like" bridges (Fig. 1c).

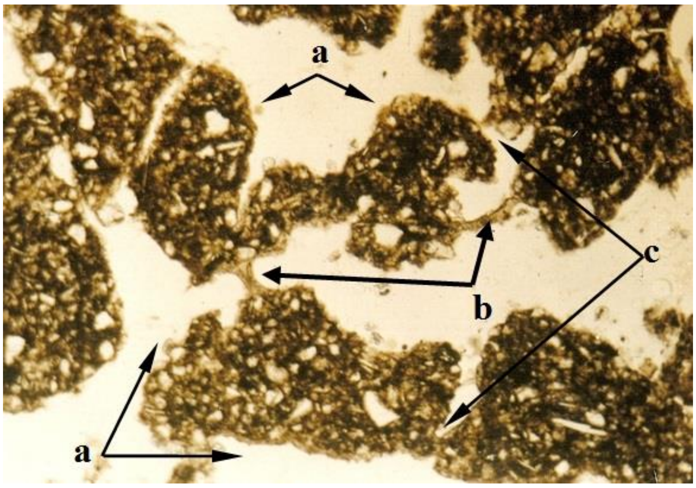


Fig.1. The structural conditioner (Ponilit GT-1 + hematoxylin) formed films on soil aggregate surfaces (a) as well as interpedal bridges: “strings” (b) and “meniscus” (c).

The “strings” bridges usually have < 5 µm (diameter) and the length of 30 - 180 µm, while “meniscus-like” bridges have 12 – 15 µm.

The distance between aggregates (according to the degree of pedality) influenced the type of conditioner bridges. If the distance between aggregates is higher, “strings” bridges are formed (Fig. 1b and 2b), while when the distance is shorter, the contact of their surfaces is larger, and as a result, the “meniscus-like“ bridges are formed (Fig. 1c and 2c). The second type is more common than the first, especially in the pores ranging from 12µm to 15µm.

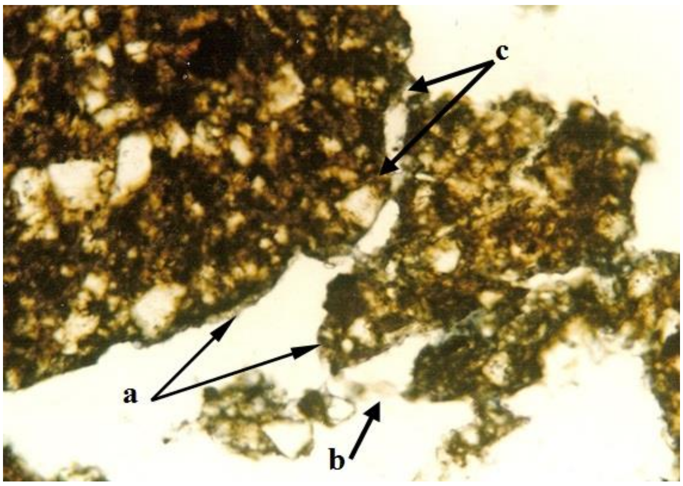


Fig. 2. The structural conditioner (Ponilit GT-1 + methylene blue) formed films on soil aggregate surfaces (a) and “strings” (b) and “meniscus” (c) interpedal bridges.

Along with its stabilizing effect, the polyelectrolyte also has aggregation effects: by bridging the small aggregates and silty size soil constituents, located in the pore space.

Forming the films (which coated aggregates or intrapedal voids) together with the bridges (which bind together either particles or aggregates), Ponilit GT-1 contributes to the strengthening of soil architecture and to the maintenance of the favorable aerohydric conditions for a good biochemical activity in soil.

CONCLUSIONS

The results of the micromorphological investigation of the behavior of a soil conditioner (Ponilit GT-1), stained with dyes (hematoxylin and methylene blue), draw the following conclusions:

- The method used to mark the structural conditioner with two types of dyes (hematoxylin and methylene blue) was very efficient, allowing the study of its distribution in the soil.
- The conditioner easily penetrates into the soil (either into the interpedal or into intrapedal voids) forming thin films on soil aggregates surface impeding their collapse and bridges between aggregates, strengthening the architecture of the soil.
- The conditioner has formed two types of bridges: “strings” and “meniscus-like‟ bridges.
- The conditioner has formed thin films on the intrapedal void walls, promoting a good circulation of air and soil solution, and further a good biochemical activity.

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