Soil revitalization through prebiotic solutions – a microbiological approach to sustainable fertility in clay soils under the temperate conditions of Southern Romania

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INTRODUCTION

Prebiotic soil products represent a new generation of biotechnologies designed to revitalize the biological activity of the soil, by stimulating indigenous microorganisms involved in the processes of decomposition of organic matter and humus formation. These solutions do not contain live microorganisms, but natural organic compounds that reactivate the existing microbial flora, contributing to the restoration of the balance between mineralization and humification - fundamental processes for maintaining soil fertility.

MATERIALS AND METHODS

The study was conducted at the Moara Domnească Experimental Base (RDSFG Băneasa), on clay soil characteristic of the temperate region of southern Romania.
The experiment included three variants: untreated control, K1–100%, and K1–200%, applied over an area of 100 square meters.
In each variant, standardized indicator materials (cellulose and cotton strips) were placed in the soil at a depth of 30–40 cm to evaluate decomposition activity.
Biological and physical soil parameters were monitored, including the degradation level of the indicator materials, soil compaction, and drainage behavior, in order to determine the effect of different concentrations of the prebiotic product K1 on soil mineralization processes and soil structural development. The prebiotic was applicated in October 2025

Fig. 1. The application of the treatment dose in the experimental plot within the Moara Domnească experimental plantation

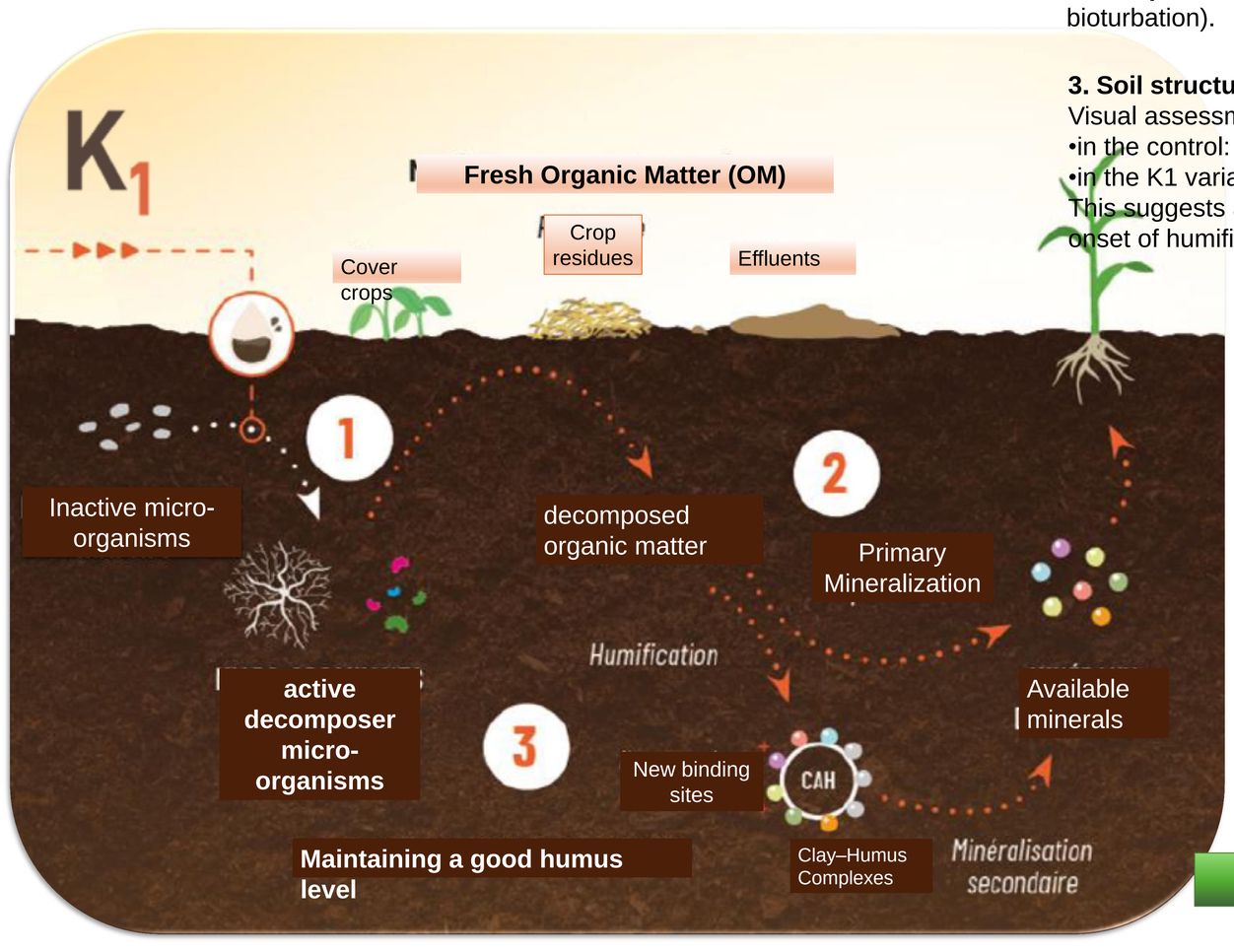

Fig. 2. The application of the treatment dose in the experimental plot within the Moara Domnească experimental plantation

Fig. 3. Applied field research in the experimental plot within the Moara Domnească experimental plantation

3. RESULTS AND DISCUSSION

1. Microbial activity and decomposition of indicator materials
The analysis of the cellulose and cotton strips recovered from the soil shows:
the control displays areas with limited degradation, still-visible fibrous structure, and a relatively compact texture;
the K1 treatment at 5 L/ha shows **much more advanced degradation**, with fragmented fibers, a weakened overall structure, and numerous micro-traces of biological activity on the material surface.
These differences confirm the hypothesis that **the intensity of the decomposition process is proportional to the applied dose**, indicating accelerated activation of saprophytic micro-organisms in the treated variants.

2. Soil compaction level (measured with the FieldScout penetrometer)
The images show the use of the SC900 penetrometer, which recorded soil penetration resistance.
In the K1-treated areas, the soil exhibits a **looser structure**, visible both visually (smaller, more friable aggregates) and in initial measurements (lower penetration resistance values).
The control displays larger, more compacted aggregates and higher mechanical resistance.
This result aligns with the hypothesis that **stimulated microbial activity contributes to natural micro-decompaction**, through biochemical and physical processes (creation of porosity, root activity, and biological bioturbation).

3. Soil structure and aggregate distribution
Visual assessment of soil samples sieved in structural analysis boxes shows:
•in the control: large, irregular, sometimes compact aggregates;
•in the K1 variant: **more uniform, smaller aggregates**, passing more easily through the sieve.
This suggests an **early trend of structural improvement**, associated with increased biological activity and the onset of humification processes.

4. Presence of soil organisms
In detailed images of the soil profile, one can observe:
fine galleries, channels likely created by micro-organisms, roots, or soil fauna;
the presence of an **earthworm** in the treated area, a classic indicator of enhanced biological activity.
Soil fauna is closely linked to the availability of decomposed organic matter and improved physical conditions (moisture, aeration). Its presence in the treated variant is a positive signal of **early biological revitalization**.

5. Moisture and drainage
Field images and soil texture indicate that:
the treated soil retains moisture **more evenly distributed**, with a more granular structure,
while the control shows zones of clumping and possible micro-stagnation.
These observations are consistent with the biological effects of accelerated decomposition, which lead to **increased porosity and improved water infiltration**.

4. CONCLUSIONS

The preliminary results of this study indicate that the application of the prebiotic solution K1 produces significant biological and physical effects on the clay soil typical of the temperate region of southern Romania. The cellulose and cotton indicator materials showed accelerated decomposition in the treated variants, confirming the hypothesis that the intensity of the process is proportional to the applied dose.
Penetrometer measurements and visual aggregate analysis revealed a reduction in soil compaction and early improvement in soil structure, supported by the presence of biological channels and active soil fauna.
The more uniform moisture distribution and improved drainage observed in the treated soil suggest increased porosity and intensified microbiological processes responsible for humification and mineralization.
Overall, the findings support the potential of prebiotic solutions such as K1 to **revitalize soil**, **reactivate the organic matter cycle**, and contribute to the **maintenance of long-term soil fertility** in agroecosystems. These results position prebiotic technologies as a promising component of modern **sustainable agriculture and carbon farming strategies**.