

RESEARCH ON THE INFLUENCE OF ORGANIC AND MINERAL FERTILIZATION ON THE PHYSICAL PROPERTIES OF THE SOIL IN COVASNA COUNTY

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Abstract

As an important pawn in intensive agriculture, fertilizers are identified, whether organic or mineral, whit their specific effects on the physical properties of the soil, which is what this study aims to do. The application of mineral fertilizers has a quick and predictable effect, but with higher acquisition and application costs. At the same time, for a long term, they have side effects, such as decreased soil fertility and soil toxicity. Organic fertilizers improve soil structure, texture and water retention capacity, leading to more optimal development conditions for the plant root. Also, organic fertilizers are a much more affordable option for farmers, but somehow more difficult to handle and manage. Therefore, the work will track the value of some important soil physical properties such as soil reaction, humus content, bulk density, degree of settling and porosity, in relation to different doses of organic, mineral and organo-mineral fertilizer applied in an experimental sugar beet field in Covasna County.

Key words: compaction degree, density, mineral fertilizer, organic fertilizer, porosity, soil fertility.

INTRODUCTION

Soil can be defined as the surface layer of the Earth's crust, consisting of mineral particles, organic matter, water, air, and living organisms. It is a highly dynamic system that performs many functions and is vital to human activities and the survival of ecosystems (Brady et al., 2008).

The action of various natural or anthropogenic factors leads to soil degradation, significantly reducing in the medium and long term the area of land that can be used for agricultural purposes (Lal, 2001). These processes of soil degradation, especially those used in agriculture, represent a serious environmental and socio-economic problem (Oldeman et al., 1990; Rounsevell et al., 2010). Thus, agricultural land represents a strategic resource, the loss of land due to various causes can generate food crises and social turmoil (Alexandratos & Bruinsma, 2012). The restrictions imposed by these limiting factors can act singly or in conjunction, resulting in a decrease in soil quality and even the cancellation of their functions. The main restrictions on the quality of agricultural soils are: drought, periodic excess of moisture, water

erosion of the soil, landslides, wind erosion, excessive skeleton on the soil surface, salinization, secondary compaction due to improper work, primary soil compaction, crust formation, low-extremely low humus reserve, strong and moderate acidity, poor and very poor provision of mobile phosphorus and potassium, low content of nitrogen, deficiencies of microelements, physical and chemical pollution; covering of land with waste and solid residues.

In Covasna County, a series of limiting factors on the production capacity of soils are manifested, such as nitrogen and phosphorus deficit, which affect 111,338 ha and 102,660 ha respectively, to which are added significant areas affected by pseudo-gleyization processes (63,495 ha) and gleyization (43,564 ha), as well as potassium (49,282 ha) and organic matter (30,159 ha) deficits. Regarding the coverage of soil with waste and solid residues, it is found that 840 ha are affected by various excavation works.

Soil fertility is essential for agricultural productivity, and the use of organic and mineral fertilizers significantly influences its physical properties. Parameters such as bulk density, total porosity, and compaction degree

reflect the structural state of the soil and its ability to support crops. Studies show that adequate fertilization can improve these properties, contributing to sustainable agriculture.

The predominant soils in Covasna County are chernozems, reddish-brown soils, and podzolic soils, each with distinct physical characteristics. These are influenced by climatic factors, vegetation types, and intensive agricultural activity (Rusu et al., 2013).

On the highest peaks, brown podzolic mountain soils are found, which are characterized by high acidity and a high content of organic matter. Another type of soil is brown and brown acid forest soils, which are more widespread in the Baraolt Mountains, but also appear in islands in the Bodoc, Vrancei and Întorsurii Mountains. The largest area of Covasna County is occupied by brown and clay-iluvial podzolic soils. These soils are found especially on the wide and low peaks, as well as on the slightly inclined slopes of the Întorsurii, Vrancei, Nemira, Bodoc and Baraolt Mountains. Leached chernozems or pratazioms are found especially around the city of Târgu Secuiesc, Câmpu Frumos. In the lowest part of the county, we find hydro-morphic soils with the subgroups of gleyic, humic-gleyic soils and eutrophic peats, these being used especially for pastures and hayfields because they present a low degree of fertility and an excess of humidity, especially during the rainy periods of the year. Another category of soils that is found near the locality of Reci, on an area of approximately 18 km², is represented by unsoiled sands, mentioned in the specialized literature as "The Dunes of Reci".

Organic fertilization involves using compost, manure, and other organic materials that improve soil structure and increase organic matter content (Muntean et al., 2011) and mineral fertilization involves the application of chemical fertilizers providing essential elements such as nitrogen, phosphorus, and potassium. It directly impacts plant growth but can negatively affect soil structure when overused (Dobrovolski, 2001).

Effects on soil physical properties

Organic fertilization stabilizes soil aggregates and increases porosity, promoting water infiltration and reducing erosion risk. In contrast, excessive mineral fertilization can

lead to soil compaction and reduced structural stability (Lal, 2004).

Organic matter improves water retention capacity by creating a porous and stable environment. Mineral fertilization, especially excessive nitrogen application, can reduce this capacity by destroying natural soil aggregates (Brady et al., 2008).

Adding compost and manure reduces bulk density and increases total porosity, facilitating root development. Chemical fertilizers can lead to soil compaction when misused (Hillel, 1998).

Organic fertilization positively affects the physical properties of the soil, improving structure, porosity, and water retention capacity. Mineral fertilization, although essential for agricultural productivity, can have negative effects on soil structure if misused. In Covasna County, the combined application of both types of fertilization represents an optimal solution for maintaining soil health.

Soil tests are extremely important before establishing a crop, as they help farmers determine whether the soil type is suitable for the plants to be grown, but also for establishing an appropriate fertilization plan.

For sampling, a spade, probe, cylinders or other available tools can be used. It is important to remember that the tools used must be clean and rust-free, so as not to contaminate the soil samples.

Regarding the soil sampling points, they can be taken in a zig-zag, diagonal or other ways, depending on the configuration of the land, being considered partial samples. There are made from 15 to 20 such partial samples.

This study analyzes how different types of fertilization influence the physical properties of the soil in Covasna County, based on collected and analyzed samples.

MATERIALS AND METHODS

Soil samples were collected at depths of 0-20 cm, from Covasna County, Zăbala village. There is also where the research takes place, on a demonstration plot of 1.5 hectares.

The climatic conditions of the area can be characterised by an average annual temperature of 10.64°C, and 500-600 mm/year precipitations.

The soil on which the experiment was located showed a pH value of 6.13, being classified as acidic soil. Low values were identified for potassium (K) – 13.5 mg/kg, phosphorus (P) – 10.4 mg/kg, calcium (Ca) – 36.8 mg/kg, magnesium (Mg) – 10.4 mg/kg, and zinc (Zn) – 0.6 mg/kg; normal values for sodium (Na) – 8.2 mg/kg, manganese (Mn) – 17.7 mg/kg, and boron (B) – 0.3 mg/kg; and high values were identified for iron (Fe) – 105.9 mg/kg and copper (Cu) – 1.6 mg/kg.

To assess the efficiency of mineral and organic fertilizers, the variants are compared with the control (unfertilized).

The research involves three sugar beet hybrids: Darvas, Deseda and Tatry, that were fertilized with organic, mineral and organo-mineral fertilizers as follows: 20 t/ha manure, 20 t/ha manure + 150 kg/ha N + 150 kg/ha P + 150 kg/ha K, 10 t/ha manure, 10 t/ha manure + 150 kg/ha N + 150 kg/ha P + 150 kg/ha K, only mineral fertilization with 150 kg/ha N + 150 kg/ha P + 150 kg/ha K and the control (unfertilized) (Table 1).

The mineral fertilizer used was Azomures NPK Complex 15-15-15 which is a solid fertilizer specially formulated to provide complete and balanced nutrition to plants. It contains equal proportions of nitrogen (N), phosphorus (P) and potassium (K), making it ideal for a wide range of agricultural and horticultural crops. It contributes to the vigorous and healthy growth of plants.

Table 1. The experimental factors

Fertilizer/ Hybrid	a1: DARVAS	a2: DESEDA	a3: TATRY
b1: 20 t manure/ ha	a1b1	a2b1	a3b1
b2: 20 t manure/ ha + 150 kg/ha N + 150 kg/ha P + 150 kg/ha K	a1b2	a2b2	a3b2
b3: 10 t manure/ ha + 150 kg/ha N + 150 kg/ha P + 150 kg/ha K	a1b3	a2b3	a3b3
b4: 10 t manure/ ha	a1b4	a2b4	a3b4
b5: 150 kg/ha N + 150 kg/ha P + 150 kg/ha K	a1b5	a2b5	a3b5
b6: control (unfertilized)	a1b6	a2b6	a3b6

The physical properties analyzed were: bulk density (Da, g/cm³) – indicates the degree of compaction and soil porosity, total porosity (PT, %) – reflects the soil's ability to retain water and air and compaction degree (GT, %) – provides information on structural changes in the soil relative to a reference state.

The soil samples were collected using metal cylinders from each variant and repetition of the study, in November 2024.



Figure 1. Metal cylinders with a volume of 100 cm³

The cylinders were marked and numbered to distinguish each other, and the samples collected were later analyzed at the soil science laboratory of the University of Agronomic Sciences and Veterinary Medicine of Bucharest (Figures 1 and 2).



Figure 2. Collected soil samples in metal cylinders

RESULTS AND DISCUSSIONS

Bulk density (g/cm³)

Soil bulk density is the ratio of the mass to the bulk or macroscopic volume of soil particles plus pore spaces in a sample (Blake, 1965). Bulk density of a soil is a dynamic property that varies with the soil structural conditions. In general, it increases with profile depth, due to

changes in organic matter content, porosity and compaction (Chaudhari et al., 2013).

At the average level, the lowest bulk density value was recorded for variant a2b1 - 1.17 g/cm³, respectively the Deseda hybrid fertilized with 20 t of manure/ha. The control variant a2b6, unfertilized Deseda hybrid, has a bulk density of 1.33 g/cm³, the difference between a2b1 and a2b6 being -0.160 g/cm³. Following the statistical analysis, the difference

between a2b1 and a2b6 is classified as very significant.

The differences between variants a1b1, a1b2, a1b3, a1b4, a2b2, a2b5, a3b1, a3b2 and their control variants are also classified as very significant.

The remaining variants, according to Table 2, are classified as having no significant differences at all in bulk density.

Table 2. Statistical analysis of bulk density data

Fact A	The influence of experimental factors on bulk density								
	a1 - DARVAS			a2 - DESEDA			a3 - TATRY		
Fact B	Value g/cm ³	Difference g/cm ³	Significance	Value g/cm ³	Difference g/cm ³	Significance	Value g/cm ³	Difference g/cm ³	Significance
b1	1.267	-0.065	***	1.17	-0.160	***	1.212	-0.117	***
b2	1.207	-0.125	***	1.247	-0.082	***	1.147	-0.182	***
b3	1.315	-0.017	***	1.382	0.052	-	1.342	0.012	-
b4	1.305	-0.027	***	1.362	0.032	-	1.330	0.001	-
b5	1.375	0.042	-	1.277	-0.052	***	1.335	0.005	-
b6	1.333	Mt	-	1.33	Mt	-	1.33	Mt	-
DI 5%= 0.113; DI 1%= 0.151 DI 0.1%= 0.197									

Total porosity (%)

The geometry of the pore system of soil is just as complex as that of the solid phase.

Porosity is the percentage of the soil volume occupied by pore spaces. The types of pores present in a soil are as important as the amount of pore space. Pore spaces are filled with air or water. Pore space is divided into different categories by pore diameter, especially the large soil pores that are associated with the transfer and movement of both water and air. In many cases, pore-size distribution is considered the best indicator of the soil physical condition (Hao et al., 2008).

Organic fertilization contributes to increasing soil porosity, favoring microbiological activity. Regarding total porosity, the largest very significant difference was identified at variant a1b5, the Darvas hybrid fertilized with

150 kg/ha N + 150 kg/ha P + 150 kg/ha K, respectively 45.03%, 2.29% less than the unfertilized control variant of this hybrid, a1b6, which recorded 47.32% total porosity.

Very significant differences were also recorded at variants a1b4, a2b3, a3b4, a3b3, a3b5 compared to the specific control of each variant.

Distinctly significant differences were marked at variants a2b1 and a3b2 with variations ranging between 6.37% and 7.14% compared to the control variants of each hybrid.

According to Table 3, only the value obtained by the Tatry hybrid fertilized with 20 t of manure/ha marked significant differences, due to the 4.61% difference between its value, 51.45%, and the value of the unfertilized control variant, i.e. 46.85%.

Table 3. Statistical analysis of total porosity data

fact A	The influence of experimental factors on total porosity (%)								
	a1 - DARVAS			a2 - DESEDA			a3 - TATRY		
	Value %	Difference %	Significance	Value %	Difference %	Significance	Value %	Difference %	Significance
fact B									
b1	49.39	2.07	-	53.13	6.37	**	51.45	4.61	*
b2	51.71	4.38	-	50.11	3.64	-	53.99	7.14	**
b3	47.34	0.02	-	44.63	-2.13	***	46.23	-0.61	***
b4	47.22	-0.09	***	45.58	-1.18	***	46.96	0.11	-
b5	45.03	-2.29	***	49.01	2.24	-	46.55	-0.29	***
b6	47.32	Mt	-	46.76	Mt	-	46.85	Mt	-
DI 5%= 4.572									
DI 1%= 6.10									
DI 0,1%=7.991									

The compaction degree (%)

Soil compaction affects hydraulic properties, and thus can lead to soil degradation and other adverse effects on environmental quality (Zhang et al., 2006).

Soil compaction is an important component of the land degradation syndrome which is an issue for soil management throughout the world.

The principal causes are when compressive forces derived from wheels, tillage machinery and from the trampling of animals, act on compressible soil. Compact soils can also be found under natural conditions without human or animal involvement. Compaction alters many soil properties and adverse effects are mostly linked to a reduction in permeability to air, water and roots (Batey, 2009).

The application of organic fertilizers can reduce soil compaction, improving its permeability.

Regarding the soil compaction degree, Tatry hybrid fertilized with 20 t of manure / ha + 150 kg/ha N + 150 kg/ha P + 150 kg/ha K (a3b2) recorded the percentage value of -14.985%, thus marking the greatest difference compared to the unfertilized Tatry control (a3b6), respectively -15.217%, which marks a very significant difference.

Very significant differences are recorded for each of the three hybrids studied, namely: Darvas a1b1, a1b2, a1b3 and a1b4; Deseda a2b1, a2b2 and a2b5; Tatry a3b1 and a3b4.

The remaining variants, according to Table 4, are classified as having no significant differences at all in compaction degree.

Table 4. Statistical analysis of compaction degree data

Fact A	The influence of experimental factors on compaction degree (%)								
	a1 - DARVAS			a2 - DESEDA			a3 - TATRY		
	Value %	Difference %	Significance	Value %	Difference %	Significance	Value %	Difference %	Significance
Fact B									
b1	-5.192	-5.097	***	-13.162	-13.572	***	-9.585	-9.817	***
b2	-10.132	-10.037	***	-6.717	-7.127	***	-14.985	-15.215	***
b3	-8.32	-0.737	***	4.955	4.545	-	1.542	1.31	-
b4	-5.85	-0.487	***	4.427	4.017	-	-0.015	-0.247	***
b5	4.09	4.185	-	-4.375	-4.785	***	0.86	0.627	-
b6	-0.095	Mt	-	0.41	Mt	-	0.232	Mt	-
DI 5%=9.691									
DI 1%=12.942									
DI 0.1%=16.939									

CONCLUSIONS

Organic fertilization positively affects the physical properties of the soil, improving structure, porosity, and water retention capacity. Mineral fertilization, although essential for agricultural productivity, can have negative effects on soil structure if misused. In Covasna County, the combined application of both types of fertilization represents an optimal solution for maintaining soil health.

The study highlighted that fertilization influences the physical characteristics of the soil, especially bulk density and total porosity. The results suggested that:

- the analyzed soil has a structure favorable for cultivation, but there are differences between fertilization variants;
- optimal bulk density and adequate porosity can be maintained by using organic fertilizers, which improve soil structure and support microbiological activity;
- continuous monitoring of the soil's physical properties is essential for maintaining long-term fertility.

Following the measurements, Deseda (a2b3) and Tatry (a3b2) variants registered the highest and the lowest values of the elements analyzed. The fact that Deseda a2b3 had the highest average value of bulk density (1.38 g/cm^3) was subsequently reflected in the total porosity index, which recorded the lowest average value (44.63%). The highest value of the compaction degree for Deseda a2b3 (4.95%) variant occurred as an effect of the deficient values of the other targeted elements.

Tatry a3b2 has the lowest average values in terms of bulk density (1.15 g/cm^3), which is why total porosity managed to reach such a high average value (53.99%). Regarding the compaction degree for Tatry a3b2 variant, the fact that it is negative (-14.98%) highlights the extremely good aeration of the soil.

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