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SOIL QUALITY AND THE EVOLUTION OF PHYSICO-CHEMICAL PROPERTIES IN CONSERVATIVE AGRICULTURE SYSTEM

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Abstract

The results obtained at the Albatros Farm on the Great Brăila Island, after the pea crop, are presented. The farm is located on alluvial soil, with weak gleying processes on higher grounds and strong in the low area. Samples were collected every 10 cm down to a depth of 50 cm.

Soil works were carried out with a Joker, which ensures a partial incorporation of plant residues at a depth of 8-10 cm, using a conservative approach, with plant residues partially incorporated into the soil. Fertilisation was carried out with mineral fertilisers: 60 kg N/ha, 58.5 kg P2O5/ha, and 23.4 kg S/ha. The expected yield was 3500 kg/ha, while the actual yield was 5507 kg/ha, with a difference of 2007 kg/ha (57.3%).

The chemical characteristics of the soil are: a mildly alkaline reaction, pH ranging between 7.78 and 8.11, medium humus content, high total nitrogen content, high total phosphorus and very high mobile phosphorus in the first 30 cm, medium and high total and mobile potassium content, high sulfur content and high cation exchange capacity values, it can be appreciated that in this respect the farm's soil has a high fertility potential.

The physical and chemical characteristics of the soil highlight the application of proper agricultural technologies that lead to a continuous improvement of soil quality and an increase in both production and product quality. No accumulation of heavy metals in the soil that would limit the quantity or quality of production has been observed.

***Key words**: alluvial soils, peas, mineral fertilizers*

INTRODUCTION

In the 2012 Thematic Strategy for Soil, the European Union recognises the need to develop a Soil Framework Directive that provides a legal instrument to ensure soil productivity, prevent risks to human health and the environment, and offer opportunities to limit and adapt to climate change while at the same time stimulating business and soil remediation opportunities. It started from the knowledge that soil and the multitude of organisms living in it provide us with food, biomass and fibres, raw materials, regulate the water cycle, as well as carbon and nutrient cycles, and make life on land possible.

It takes thousands of years to produce a few centimetres of this magical carpet. Soil hosts over 25% of the planet's entire biodiversity and is at the base of the food chains that feed humanity and, above it, biodiversity (EC, EU Soil Strategy for 2030, 2021).

Since the proposal of the Soil Protection Directive in 2007, the theme for soil protection has been established as its sustainable use, protecting and restoring the soil's capacity to provide one or more of the following environmental, economic, social, scientific, and cultural functions: a) biomass production, including in agriculture and forestry; b) storage, filtration, and transformation of nutrients, substances, and water; c) a basis for the life and biodiversity reservoir, such as habitats, species, and genes; d) the physical and cultural environment for humans and human

activities; e) a source of raw materials; f) acts as a carbon reservoir.In this international context, Romania has drafted Law 246/2020 regarding the use, conservation and protection of soil, which among other things stipulates the following:
a) Systematic, permanent, detailed, quantitative and qualitative knowledge of soils, as a non-renewable natural resource, at the level of each cadastral parcel;
b) Monitoring the evolution of soil quality status;
c) Identification of natural and/or anthropogenic risk areas for: desertification, erosion, excess and/or deficiency of moisture, compaction, acidification, salinization, alkalinization, decrease in organic matter and nutrient content, reduction of biodiversity, and landslides, in order to mitigate them; d) The balance of nutrients, organic matter, and soil pH to determine the optimal doses of fertilisers and amendments for all land users, at the plot level, etc.
In order to monitor soil quality evolution and avoid negative impacts on agricultural production, human and animal health, and to protect the soil, it is necessary to issue a Soil Quality Certificate. Requesting and obtaining the soil quality certificate is mandatory when changing the landowner/alienating the land under any valid title, the land user, the mode of use, or when returning the land to the owner after use in lease, concession, or any other form of exploitation.
Under these conditions, an attempt was made to determine the influence of agricultural technologies applied on the Albatros farm in the Great Brăila Island, in order to examine the conditions for issuing a soil quality certificate if necessary.

MATERIALS AND METHODS

The soils on the territory of the Great Brăila Island are of alluvial nature, layered, poorly developed due to frequent floods, with weak gleying processes on the mounds and strong in the low-lying area.
Common are mollic gleyic alluvial soils, mollic saline alluvial soils, gleyic alluvial soils, saline alluvial soils, pelic gleyic alluvial soils, and associations of gleyic alluvial soils and mollic gleyic alluvial soils.
On the Great Brăila Island, stubble management with a Joker and partial incorporation of plant residues into the soil at a depth of 8-10 cm is practiced, and fertilization for the pea crop was done with 60 kg N/ha, 58.5 kg P2O5/ha, and 23.4 kg S/ha.
The following methods were used to perform the laboratory analyses:
- pH in aqueous suspension 1:2.5; SR 7184-13:2001;
- Humus: wet oxidation STAS 7184/21-82;
- Nt: total nitrogen, Kjeldahl method; STAS 7184/2-85;
- P_{AL}: extractable phosphorus in ammonium acetate-lactate; STAS 7184/19-82;
- K_{AL}: extractable potassium in ammonium acetate-lactate; STAS 7184/18-80;
- $S\text{-}SO_4^{2-}$: soluble sulfates, turbidimetric method; ICPA Methodology (1981);
- P_{Total}: total phosphorus, colorimetric method, ICPA Methodology (1986);
- K_{total}. Total potassium; ICPA Methodology (1981), ICPA Methodology (1986);
- $T\text{-}NH_4$: total cation exchange capacity; STAS 7184/12;
- Structural hydrostability: Henin Feodoroff method developed by INRA France adapted in ICPA;
- Cu, Zn, Fe, Mn: -mobile forms, extracted in ammonium acetate solution - EDTA, Assay by atomic absorption spectrophotometry, SR ISO 11047:1998;
- Zn, Cu, Fe, Mn, Pb, Cr, Co, Ni: - total contents by atomic absorption spectrometry, ICPA Methodology (1981), SR ISO 11047;

The interpretation of the results was carried out according to "Methodology of Elaboration of Pedological Studies", 1987, N. Florea et al., ICPA – Bucharest and "Global Soil Chemistry, Processes, Determinations, Interpretations", 2017, R. Lăcătușu et al.

RESULTS AND DISCUSSIONS

It is estimated that by incorporating this legume into the cropping system, soil fertility is improved and crop yields increase.

The benefits of integrating legumes into the cropping system can be attributed to various factors, such as direct nitrogen transfer, the presence of residual fixed nitrogen, improved nutrient uptake and availability, a positive impact on soil properties, disruption of the life cycles of pests and diseases, and stimulation of biological activities in the soil (Jimenez – Lopez and Escudero-Feliu, 2025).

The applied fertilizer dose was sufficient for the pea crop, as the expected yield was 3500 kg/ha, and the obtained yield was 5507 kg/ha, with a difference of 2007 kg/ha (57.3%). Introducing peas into the crop rotation leads to increased biomass production, increased reserves of both stable and labile fixed carbon, biologically fixes large amounts of nitrogen, releases low molecular weight organic compounds into the rhizosphere that increase biological activity in the soil, thus aiding nitrogen fixation, phosphorus solubilization, CO2 sequestration, enhancing microbial diversity in the rhizosphere, increasing inorganic P and N levels, and improving soil structure. All these changes lead to the improvement of soil health. On average, the bean:vine ratio is estimated to be 1:1.5. It is considered that, to produce a yield of one ton of beans, a pea crop consumes, on average, 60 kg of N, 8 kg of P_2O_5, 30 kg of K_2O, 25 kg of CaO, and 6 kg of Mg (Muntean et al., 2003). The majority of the nitrogen required by pea plants (42–75%) is supplied by the activity of nitrogen-fixing bacteria. The rest comes from soil reserves or from the remnants of fertilizers applied to the previous crop. Phosphorus is important in the development of peas, positively influencing the formation of nodules and thus nitrogen fixation, and it results in more abundant flowering and better fruit set. Peas respond strongly to phosphorus deficiency (Roman et al., 2011). High doses of phosphorus lead to a significant increase in the protein content of pea seeds (Călinoiu and Călinoiu, 2003). At harvest, 30-100 kg N/ha remain in the soil (Muntean et al., 2003).

The data presented in Table 1 show that the soil has a silty clay texture for all soil samples collected. The carbonate content is 0.2% at depths greater than 30 cm.

Table 1. Particle size analysis of soils from the Albatros Farm

Identification		Particle size fractions (in mm) (% of the mass of the mineral part of the soil)											Symbol	Carbonates
		Coarse sand					Fine sand				Dust	Clay	Textural Class	
Proba	h (m)	2.0-0.2	2-1	1-0.5	0.5-0.2	0.2-0.02	0.2-0.1	0.1-0.05	0.05-0.02	0.02	0,002	0.01		(%)
Pr 1	0-10	1.0	0.3	0.2	0.5	9.1	0.5	0.1	8.5	33.4	56.5	80.9	AP	-
Pr 1	10-20	0.8	0.3	0.2	0.3	6.6	0.3	0.1	6.2	35.3	57.3	84.4	AP	-
Pr 1	20-30	0.9	0.1	0.2	0.6	7.5	0.5	0.2	6.8	34.7	56.9	81.9	AP	-
Pr 1	30-40	2.5	1.0	0.5	1.0	6.4	0.3	0.3	5.8	35.7	55.4	81.3	AP	-
Pr 1	40-50	0.6	0.1	0.2	0.3	8.3	0.3	0.2	7.8	38.1	53.0	81.4	AP	-
Pr 2	0-10	0.5	0.1	0.1	0.3	10.7	0.5	0.2	10.0	36.3	52.5	79.4	AP	-
Pr 2	10-20	0.3	0.0	0.1	0.2	8.2	0.3	0.2	7.7	41.2	50.3	80.3	AP	0.2
Pr 2	20-30	0.3	0.0	0.1	0.2	7.6	0.3	0.1	7.2	37.4	54.7	82.2	AP	-
Pr 2	30-40	0.3	0.0	0.1	0.2	8.1	0.3	0.2	7.6	37.2	54.4	59.9	AP	0.2
Pr 2	40-50	1.2	0.3	0.3	0.6	14.8	0.6	0.3	13.9	33.6	50.4	76.1	AP	-
Pr 3	0-10	1.0	0.2	0.2	0.6	12.0	0.9	0.2	10.9	37.9	49.1	77.7	AP	0.2
Pr 3	10-20	1.6	0.5	0.4	0.7	11.2	0.4	0.2	10.6	36.4	50.8	78.5	AP	0.6
Pr 3	20-30	1.3	0.3	0.2	0.8	11.5	0.6	0.2	10.7	37.9	49.3	78.5	AP	0.2
Pr 3	30-40	1.2	0.2	0.5	0.5	12.6	0.6	0.2	11.8	35.9	50.3	77.1	AP	0.2
Pr 3	40-50	1.4	0.2	0.4	0.8	11.9	0.8	0.2	10.9	36.0	50.7	77.9	AP	0.4

The data presented in Table 2 show that the structural hydrostability of the soil (AH), represented by structural microformations stable under the action of water, is high down to a depth of 50 cm; dispersion (D), represented by microformations with a diameter <0.001 mm unstable under the action of water, has extremely high values and leads to high values of the structural instability index (IS). Water circulation in the soil to a depth of 50 cm is very good.

High structural hydrostability is ensured by a positive humus balance, the presence of calcium carbonate, maintaining soil reaction and the composition of exchangeable cations within optimal limits (Canarache, 1990), using good quality water for irrigation, ensuring a low water intensity during sprinkler irrigation, promoting the activity of mesofauna, and using a varied crop structure.

The high hydrostability of structural aggregates is ensured by the high clay content, organic matter, and the presence of divalent calcium cation (Dumitru et al., 1998).

Table 2. Some physical characteristics of the soil in Albatros Farm

Identification	h (cm)	AH	D	IS
pr. 1	0-10	43	29	1
pr. 1	10-20	39	25	1
pr. 1	20-30	51	28	1
pr. 1	30-40	43	32	1
pr. 1	40-50	34	30	1
pr. 2	0-10	52	30	1
pr. 2	10-20	43	30	1
pr. 2	20-30	43	28	1
pr. 2	30-40	54	31	1
pr. 2	40-50	43	32	1
pr. 3	0-10	50	30	1
pr. 3	10-20	54	25	0
pr. 3	20-30	50	30	1
pr. 3	30-40	45	29	1
pr. 3	40-50	53	18	0

The data presented in Table 3 show that the soil on the Albatros farm has a slightly alkaline reaction, a medium humus content, a high total nitrogen content, a high total phosphorus content, and a very high mobile phosphorus content in the top 30 cm, which remains high at depths of 30–50 cm, a medium to high total and mobile potassium content, a high sulfur content, and high cation exchange capacity values, indicating that, from this point of view, the farm's soil has a high fertility potential.

Table 4 shows the level of heavy metal total forms in the soil of the Albatros farm. The data highlight the following: a normal zinc content, a copper content slightly above the normal level but well below the alert threshold, a normal iron content, a normal manganese content, values slightly higher than normal for lead but much lower than the alert threshold, values higher than the normal level for chromium, with levels reaching over 50% of the alert threshold, normal cobalt values, and values above the alert threshold for nickel. In soil, metals can be found in various forms that are not equally chemically and biologically active. In general, the toxic effect of a metal is determined more by the chemical form in which it occurs than by its concentration (Vrînceanu et al., 2010).

Shuman (1991) described the forms in which metals can be found in the soil:
- Dissolved in the soil solution;
- Occupying exchange positions on the inorganic constituents of the soil;
- Specifically adsorbed on the inorganic constituents of the soil;
- Associated with the organic matter in the soil;

Table 3. Chemical characteristics of the soil under the influence of agricultural management

Identification	h (cm)	pH	Humus %	Nt %	P_{AL} 1)	K_{AL}	$S\text{-}SO_4$	Ptotal	Ktotal	$T\text{-}NH_4$
					mg/kg	mg/kg	mg/kg	%	%	me/100g
Pr1	0-10	7.87	5.68	0.311	99	199	17	0.150	1.43	38.03
Pr1	10-20	7.78	5.74	0.312	78	184	20	0.151	0.99	39.03
Pr1	20-30	7.96	5.33	0.309	71	169	17	0.157	1.03	36.53
Pr1	30-40	8.02	4.38	0.252	52	163	30	0.147	0.88	37.53
Pr1	40-50	8.00	4.97	0.281	52	167	23	0.148	1.08	35.52
Pr2	0-10	7.90	6.04	0.329	87	201	20	0.154	0.88	38.53
Pr2	10-20	7.88	5.74	0.337	89	186	17	0.163	0.87	38.53
Pr2	20-30	7.92	5.86	0.290	69	175	19	0.159	1.18	37.53
Pr2	30-40	7.88	4.14	0.255	64	154	27	0.141	1.20	36.53
Pr2	40-50	8.11	4.44	0.265	44	156	30	0.149	1.21	36.03
Pr3	0-10	7.87	6.04	0.302	80	197	18	0.153	0.90	38.03
Pr3	10-20	7.85	5.86	0.345	98	197	19	0.157	1.31	38.53
Pr3	20-30	7.93	5.33	0.303	75	180	24	0.143	1.06	38.03
Pr3	30-40	8.07	4.56	0.243	53	144	22	0.147	1.22	37.53
Pr3	*40-50*	8.01	4.26	0.240	46	150	24	0.146	0.98	34.52

Table 4. The influence of agricultural management on the heavy metal content in the soil

Identification	H (cm)	Zn mg/kg	Cu mg/kg	Fe mg/kg	Mn mg/kg	Pb mg/kg	Cr mg/kg	Co mg/kg	Ni mg/kg
Pr1	0-10	80.7	41.8	40.061	704	29.0	51.0	12.5	60.2
Pr1	10-20	87.3	41.8	40.105	695	28.8	49.9	11.5	59.7
Pr1	20-30	63.9	44.8	37.729	650	32.3	58.9	15.2	70.0
Pr1	30-40	85.1	45.5	43.023	858	33.4	62.0	16.4	72.2
Pr1	40-50	87.3	42.9	41.890	704	31.3	58.3	14.5	66.6
Pr2	0-10	76.3	40.3	38.831	699	29.4	49.0	11.4	59.2
Pr2	10-20	79.1	40.6	39.832	735	28.0	51.3	12.0	58.4
Pr2	20-30	80.9	44.4	41.924	749	33.3	59.1	15.3	69.4
Pr2	30-40	82.9	44.1	41.414	621	32.8	60.4	15.3	70.5
Pr2	40-50	82.5	43.2	41.198	842	32.6	59.8	15.5	66.4
Pr3	0-10	101.5	42.2	39.912	720	29.1	51.2	13.0	59.0
Pr3	10-20	99.0	46.2	42.473	778	35.5	62.9	16.3	69.5
Pr3	20-30	74.1	45.0	39.425	681	32.7	59.0	15.8	69.1
Pr3	30-40	66.7	42.8	37.837	575	32.2	59.8	15.0	67.5
Pr3	40-50	73.6	42.5	37.733	771	31.6	57.6	14.2	65.8
Normal content (mg/kg)		<101	<21	-	<901	<21	<31	<21	<21
Alert threshold (mg/kg)		300	100	-	1500	100	100	50	50

- Precipitated in the form of simple or mixed compounds;
- Present in the structure of secondary minerals; - Present in the structure of primary minerals.

Tabelul 5. Influence of agricultural management on the content of trace elements in the soil of Albatros Farm

Identifi-cation	h (cm)	Zn mg/kg	Cu mg/kg	Fe mg/kg	Mn mg/kg
Pr1	0-10	2.1	6.2	24.9	44.9
Pr1	10-20	9.7	6.1	22.7	49.6
Pr1	20-30	5.0	6.4	25.1	42.5
Pr1	30-40	5.6	6.5	28.5	36.8
Pr1	40-50	3.1	6.8	27.6	38.2
Pr2	0-10	2.6	6.0	22.5	49.3
Pr2	10-20	2.5	6.1	23.9	44.5
Pr2	20-30	2.5	6.7	30.3	34.7
Pr2	30-40	4.0	6.7	26.4	45.8
Pr2	40-50	4.6	6.5	26.5	45.9
Pr3	0-10	3.4	6.0	22.5	18.2
Pr3	10-20	2.5	5.7	25.9	35.7
Pr3	20-30	20.2	23.5	27.8	46.1
Pr3	30-40	26.3	27.1	28.9	39.2
Pr3	40-50	8.1	6.4	24.5	44.5
Supply status					
Low		<1,5	<0.5	<5	<15
Medium		1,6 – 3,0	0,6-1,5	5-25	16-30
High		>3,0	>1,5	>25	>30

In situations where metals have entered the environment as a result of human activities, they will be found in the soil in one or more of the first five forms described above.

The observed values do not represent a risk of plant uptake for any of these metals, and cannot be attributed to agricultural technologies. They are the result of the site's history prior to drainage. The slightly alkaline reaction and the high clay and organic matter content make the risk of translocation of these metals into plants low. The data in Table 5 highlight elevated levels of trace elements (zinc, copper, iron, and manganese) in the soil of the Albatros farm. For zinc, the data show a tendency for values to increase with depth along the profile. Băjescu and Chiriac (1984) show that organic matter plays an important role in the retention of zinc in soil, forming complexes with zinc with varying degrees of solubility, involved in the migration and accumulation of Zn in soils. Thus, soluble complexes increase Zn mobility, favouring its translocation to depth, while insoluble ones reduce Zn mobility, contributing to its concentration in the bioaccumulation horizon.

Ţigănaș and Trifan (1998) highlighted that soils formed on medium and fine-textured sediments have significant reserves of trace elements inherited from the parent material. The dependence of these reserves on the parent rock is more evident in young soils, with limited weathering conditions, being less pronounced in more developed soils. The trace element values in the Danube Floodplain ranged from 0.92-4.66 ppm for zinc, 12-99 ppm for manganese, and 4.7-18.5 ppm for copper.

CONCLUSIONS

Research conducted to determine the soil quality at the Albatros farm on Insula Mare a Brăilei led to the following conclusions: The soil works are of a conservative type, with plant residues being partially incorporated into the soil. The alluvial soils on the farm are worked with a Joker, which ensures partial incorporation of plant residues to a depth of 8-10 cm.

The fertilisation system was balanced, leading to very high yield increases for the pea crop. Introducing the pea crop into the crop rotation brought multiple environmental benefits.

The soil is well supplied with organic matter and nutrients, highlighting the application of correct cultivation technologies.

The soil content in total forms of heavy metals does not show values that would raise concerns regarding their translocation into the plant and the impact on the quality of the production. The entire farm area benefits from low-pressure sprinkler irrigation, which ensures protection against soil degradation. It can be appreciated that the technology practiced on the farm leads to a continuous improvement in soil quality.

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