Scientific Papers. Series A. Agronomy, Vol. LXIX, No. 1, 2026
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

ANALYSIS OF THE EVOLUTION OF SOIL FERTILITY UNDER THE INFLUENCE OF DIFFERENT TYPES OF WORKS, IN THE PEDOCLIMATIC CONDITIONS OF THE CENTRAL, SOUTHERN AND SOUTH-EASTERN REGIONS OF ROMANIA

Dragoș MANEA, Eugen MARIN, Dragoș-Nicolae DUMITRU, Alin HARABAGIU

National Institute of Research-Development for Machines and Installations Designed to Agriculture and Food Industry, 6 Ion Ionescu de la Brad Blvd, District 1, Bucharest, Romania

Corresponding author email: manea_dragos_05@yahoo.com

Abstract

This paper presents the results of research conducted by INMA Bucharest, within a complex project funded by the National Recovery and Resilience Plan, in support of the EU Mission – "A Soil Deal for Europe". The sustainable soil cultivation technology adapted to the pedoclimatic conditions in the Central, Southern and South-Eastern regions of Romania was developed for the purpose of remediation and restoration of degraded lands. The technology involved performing the following types of soil work: basic work with a plough with bodies equipped with ploughshares to break up the hardpan, in the Central region; scarification and incorporation of biofertilizers into the arable substrate in the South-East region and soil cultivation in narrow strips for sowing of weedy plants with a strip-till type equipment, in the South region. Soil samples were taken before and after applying different soil tillage options and their impact on the soil was evaluated by analyzing the following parameters: macroelements (Ca, Mg, Na, K); chemical forms of nutrients (water-soluble, exchangeable, total); other parameters (Cl^-, SO_4^{2-}, NO_2^-, NO_3^-, NH_4^+, pH).

Key words*: macroelements, mineral nitrogen, region, soil fertility.*

INTRODUCTION

Soil fertility is one of the most important factors that influence grains yields and the crop quality. Nowadays, soil degradation is a global phenomenon caused by natural land erosion, human activities and climate change. Soil fertility can be characterized by a series of agrochemical indicators: soil reaction, ion exchange capacity, degree of base saturation, nutrient content.

Of particular importance is cationic adsorption or physico-chemical retention (non-specific sorption or cation exchange), which represents the capacity of cations in the diffuse layer of soil colloids to be exchanged under equivalence conditions by cations in the soil solution. The cations of Ca, Mg, K, Na, NH_4, etc. are adsorbed and protected from leaching. From the complex, the cations gradually pass into the soil solution according to the laws of equivalent proportions, equilibrium, reversibility and retention energy (Jitareanu et al., 2020).

Agriculture methods include monoculture, synthetic inputs, bare soil, excess of tillage, due to soil degraded, unhealthy plants, animals and humans. All these methods have a negative impact on soil properties, compaction, crusted, hardpan, excess of synthetic inputs leaching in ground water, beneficial fungi and bacteria are suppressed (Hirt, 2020). Soil structure depends on the balance between calcium, magnesium and sodium. Calcium is opening the soil, makes it more friable, while magnesium and sodium close it, creating hardness that restricts, water, air and roots penetration. Carbon and nitrogen are the basic elements that provide food source for soil life (Wuddivira & Camps-Roach, 2007).

New environmentally friendly farming technologies are not possible without new tillage techniques, which also require higher soil and environmental protection requirements, the most important of which are to not deplete the soil, stop the decline of humus and soil degradation, reduce the leaching of nutrients and the most fertile soil particles, protect the soil from erosion and the breakdown of its structure, and to promote natural biological processes in the soil (Romaneckas, 2022).

Few years ago, INMA Bucharest, started a new strategy in developing new tillage implements and drilling machinery that are doing more operation on one pass to reduce fuel

consumption, soil compaction and increase soil fertility (Popescu et al., 2022).
In this context, the partners within the CeSoh complex project funded by the PNRR (National Recovery and Resilience Plan) in support of the EU Mission – "A Soil Deal for Europe" have developed a sustainable soil cultivation technology adapted to the pedoclimatic conditions in the Central, Southern and South-Eastern regions of Romania, for remediation and restoration of degraded lands (www.cesoh.ro).

MATERIALS AND METHODS

The study was conducted in four experimental sites representative of three development regions (Center, South and South-East) and pedoclimatic conditions in Romania, during the period 2023-2025. The locations were selected to cover a diversity of soil types and climatic regimes, allowing for the comparative assessment of the efficiency of innovative sustainable technologies in contrasting agroecological contexts.
The sites were located in: Dumbrăvioara (Mureș County), Gologanu (Vrancea County), Dracea (Teleorman County) and Murfatlar (Constanța County). For each location, the general soil characteristics, the history of agricultural use and the specific climatic conditions were taken into account.
The intervention carried out in the experimental site in Dumbrăvioara (Central Region) aimed to improve the physical properties of the soil affected by compaction in the sub-arable horizon, by applying a plowing technology with deep loosening and breaking of the compacted layer (hardpan). The technology aimed to improve the aerohydric regime of the soil and create favorable conditions for the development of the root system of agricultural crops. The work was carried out with a reversible plough, with bodies equipped with ploughshares (Vlăduțoiu et al., 2025a; 2005b).
The configuration of the machine and the way it works in the field are shown in Figure 1. The plow cuts, lifts, crumbles and turns the furrow, and the diggers penetrate 50-100 mm below the furrow level, fracturing the compacted layer. The hydraulic reversal allows continuous plowing, without the formation of furrows or ridges.

Figure 1. Application of basic soil tillage technology with reversible plough with bodies equipped with ploughshares, in the Dumbrăvioara experimental site (Mureș County)

The intervention at the Gologanu experimental site (South-East Region) aimed at the biological regeneration of degraded soil and the increase in chemical fertility, through the controlled application of a liquid biofertilizer formulated based on beneficial soil microorganisms.
The technology aimed to stimulate microbiological activity and improve structural aggregation under conditions of seasonal water deficit. For the implementation of the technology, innovative technical equipment was used for soil processing and inoculation of biofertilizer into the arable layer, developed within the Healthysoil Project (Marin et al., 2023; Marin & Manea, 2024). The general configuration of the machine is shown in Figure 2.

Figure 2. Application of technology with innovative technical equipment for soil processing and biofertilizer inoculation in the Gologanu experimental site (Vrancea County)

The technology allowed for the implementation, in a single pass, of deep loosening (up to 55 cm), fragmentation and leveling of the soil, simultaneously with the application of biofertilizer in the superficial layer (10-20 cm).

The controlled application of the biological solution was carried out directly in the mobilized area, to favor the contact of microorganisms with the soil matrix.
A biofertilizer produced by INMA Bucharest was used through a controlled process, whereby beneficial microorganisms and soluble organic compounds from mature, stabilized compost obtained from plant raw materials were transferred and multiplied into a liquid solution. The biofertilizer was filtered to remove coarse particles and prevent clogging of the application equipment.
The equipment was aggregated with a 220-240 HP tractor, with a 500 l tank for biofertilizer and a recommended working speed of approximately 10 km/h.
The intervention carried out in the experimental site Dracea (South Region) aimed to conserve water in the soil and prepare the seedbed for pea crops in a localized manner, under conditions of poor rainfall and increased frequency of soil drought episodes. The strip-till technology allowed soil mobilization only on the sowing strips, keeping the rest of the surface covered with plant debris. The equipment configuration is shown in Figure 3.

Figure 3. Application of technology with narrow strip tillage equipment, in the Dracea experimental site (Teleorman County)

Each working section is made up of notched discs for stubble removal, a reversible chisel knife for localized loosening and spherical discs for reforming the seedbed. The work process included uncovering a strip approximately 20 cm wide, indenting and localized loosening of the soil, forming the sowing channel and reforming the working strip, ensuring a uniform germination bed and optimal soil-seed contact.
The equipment was aggregated with an 80 HP tractor, and the tests were carried out on an experimental plot of 1 ha, under conditions of average soil moisture of 20.2% and penetration resistance between 702 and 1720 kPa. The working depth was maintained constant by the deformable parallelogram system and adjustment springs.
The intervention carried out in the Murfatlar experimental site (South-East Region), aimed at reducing the pressure of weeds, cryptogamic diseases and pests specific to viticulture, by applying biological solutions based on the use of beneficial microorganisms and biocontrol agents. The technology aimed to limit the use of synthetic phytosanitary products and maintain the biological balance of the viticultural agroecosystem, in the context of increasing climatic stress and the increased sensitivity of plantations to pathogens.
To apply the technology, a portable spraying equipment was used for phytosanitary treatments in vineyard plantations, equipped with nozzles with a fine spray spectrum and a pressure regulation system.
The intervention consisted of the repeated application, during the vegetation period, of biological treatments, adapted to the phenophases of the vine and the phytosanitary pressure observed in the field. The applications were made locally on the vine rows, respecting the doses recommended by the producers of biological solutions and alternating biocontrol products, to avoid the emergence of biological resistance. Weed control was carried out primarily through preventive and biological methods, correlated with superficial mechanical work between the rows, to limit water and nutrient competition without the use of chemical herbicides.

Experimental design and sampling scheme

To assess the impact of innovative sustainable technologies on soil fertility, a "before-after" experimental design was applied, with soil samples taken before the implementation of the interventions and after their application. In each experimental site, representative areas were delimited, homogeneous in terms of soil and agricultural use history. Soil samples were collected from two depths:

- 0-20 cm - the arable layer, of major importance for plant nutrition;
- 20-40 cm - the sub-arable layer, relevant for the assessment of leaching and nutrient mobility processes.

Composite samples were taken in each plot, consisting of 5 subsamples randomly collected from the study area, using the zigzag method, to reduce spatial variability.

Sampling points were marked and georeferenced using the Garmin GPSMAP 64s portable device, coordinates were recorded and archived to ensure traceability and comparability between sampling campaigns.

Sampling was carried out with soil probes and manual drills, respecting national and European standards regarding agricultural soil sampling.

The samples were uniformly labeled (location code, depth, sampling time, date), packaged in clean, chemically inert containers and transported under conditions that prevent contamination and modification of chemical properties.

Within the Chemistry Laboratory of the National Institute for Research and Development for Cryogenic and Isotopic Technologies I.C.S.I. Râmnicu Vâlcea, the chemical properties of the soil were determined before the application of the technologies, as well as after the implementation of the technologies proposed in the project.

The analyses targeted the following parameters: soluble and exchangeable minerals (Ca, Mg, Na, K), anion (Cl^-, SO_4^{2-}), mineral forms of nitrogen ($N\text{-}NO_2$, $N\text{-}NO_3$, $N\text{-}NH_4^+$) and soil pH.

The analytical data were organized in databases structured by: locations; soil depths; sampling time (before/after intervention); type of technology applied. The analysis included: comparison of "before-after" values; descriptive analysis (means, absolute and relative differences); interpretation of variations in relation to local pedoclimatic conditions; comparative analysis between technologies, to highlight solutions with agronomic efficiency and favorable ecological impact.

RESULTS AND DISCUSSIONS

Analysis of the evolution of water-soluble elements (Ca, Mg, Na)

The evolution of water-soluble elements (Ca, Mg, Na) represents an essential indicator of the dynamics of nutrients in the soil solution and of the impact of applied technologies on ionic balance and fertility. Monitoring these forms allows the evaluation of mobilization, leaching and vertical redistribution processes, as well as the appreciation of the sustainability of agronomic interventions.

The evolution of water-soluble elements was evaluated by calculating the absolute difference between the values determined after applying the technologies and the initial ones.

To calculate the absolute difference (ΔCa, ΔMg, ΔNa), formula (1) was used.

$$\Delta X = X_{after} - X_{before} \quad (1)$$

where X = Ca, Mg or Na, in mg/kg.

Interpretation:
- ΔCa, ΔMg, ΔNa > 0 → increase in the soluble fraction (increased mobilization/solubilization);
- ΔCa, ΔMg, ΔNa < 0 → decrease in the soluble fraction (consumption, leaching or immobilization);
- ΔCa, ΔMg, ΔNa ≈ 0 → relative chemical stability.

Figures 4 and 5 graphically present the evolution of water-soluble elements (Ca, Mg, Na), which show significant differences between the two analyzed depths.

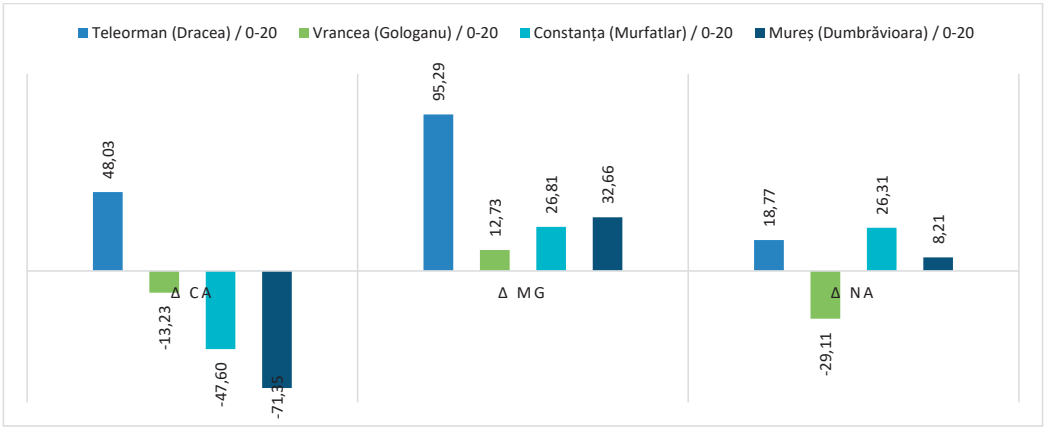
In Teleorman County (Dracea), in the 0-20 cm layer, significant increases are recorded for all the analyzed elements (ΔCa = +48.03; ΔMg = +95.29; ΔNa = +18.77). This evolution indicates a sharp mobilization of cations in the arable layer, possibly as an effect of the applied technologies. The pronounced increase in Mg suggests an increased availability for plants, with a potentially positive impact on physiological processes.

In the 20-40 cm layer, all analyzed elements maintain a positive trend (ΔCa = +37.75; ΔMg = +56.29; ΔNa = +14.90), but the amplitude of the increases is lower compared to the upper layer. This evolution suggests a relatively uniform distribution of cations in the soil profile.

In Vrancea County (Gologanu), in the superficial layer, a decrease in Ca (−13.23) and Na (−29.11) is observed, concomitant with a moderate increase in Mg (+12.73). This dynamics may indicate selective leaching or vertical redistribution processes, especially for Ca and Na.

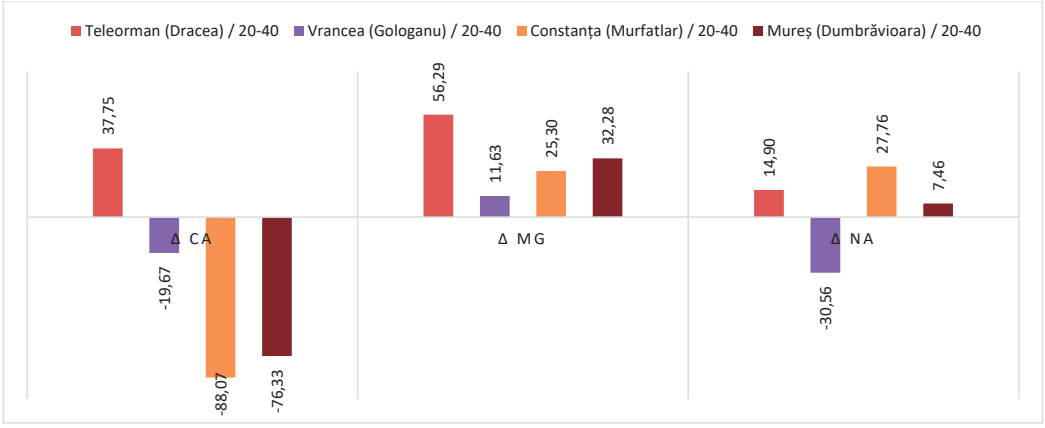
In the 20-40 cm layer, the decrease in Ca (−19.67) and Na (−30.56) is accentuated, while

Mg continues to increase moderately (+11.63). These results may indicate a higher mobility of Ca and Na and a possible migration to deeper horizons.



Note: Values represent concentrations determined in aqueous extract, expressed in mg/kg dry soil

Figure 4. Evolution of water-soluble elements (Ca, Mg, Na) at a depth of 0-20 cm, before and after the application of technologies



Note: Values represent concentrations determined in aqueous extract, expressed in mg/kg dry soil

Figure 5. Evolution of water-soluble elements (Ca, Mg, Na) at a depth of 20-40 cm, before and after the application of technologies

In Constanța County (Murfatlar), in the 0–20 cm layer, a significant decrease in Ca (−47.60) is highlighted, while Mg (+26.81) and Na (+26.31) register increases. The differentiated evolution of cations can be associated with their specific mobility in pedoclimatic conditions characteristic of the area.

In the 20-40 cm layer, the largest decrease in Ca within the study is recorded (−88.07), concomitantly with increases for Mg (+25.30) and Na (+27.76). This evolution suggests intense processes of Ca redistribution in the soil profile.

In Mureș County (Dumbrăvioara), in the superficial layer, Ca shows a sharp decrease (−71.35), while Mg (+32.66) and Na (+8.21) register moderate increases. The downward trend of Ca may suggest processes of biological consumption or migration in the profile.

In the 20–40 cm layer, the downward trend of Ca (−76.33) is maintained, while Mg (+32.28) and Na (+7.46) show moderate variations. The

relative stability of Mg between the two depths indicates a balanced distribution in the profile.
Depth analysis revealed a general trend of increasing soluble Mg in all locations, while soluble Ca recorded significant decreases in most locations, more pronounced in the 20–40 cm layer. Soluble Na showed differentiated evolutions, with potential implications for ionic balance and soil structural stability.

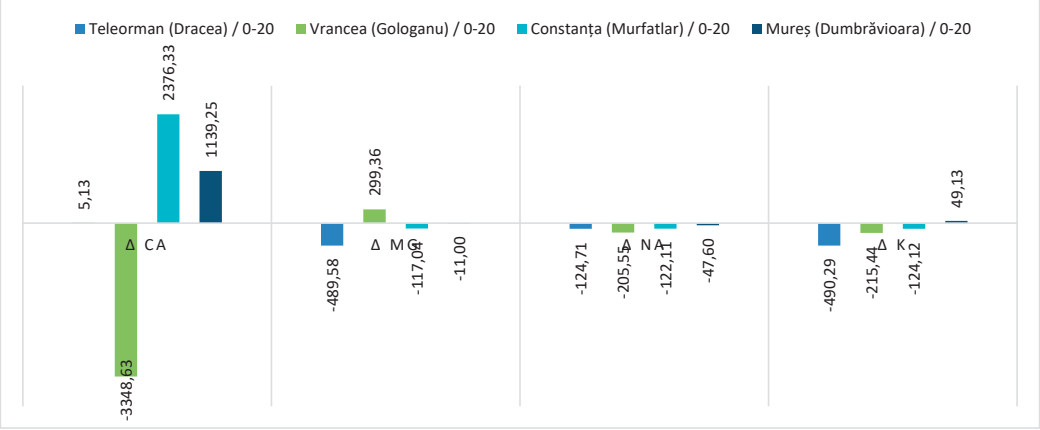
Analysis of the evolution of exchangeable cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+})

The analysis of the evolution of exchangeable cations is essential for characterizing the chemical state of the soil, as they represent the fraction electrostatically adsorbed on the colloidal (clay-humic) complex, in dynamic equilibrium with the soil solution. This fraction constitutes the active component of the cation exchange capacity and reflects both the potentially available nutrient reserve and the stability of the ionic balance.
The evolution of exchangeable cations was evaluated by calculating the absolute difference between the values determined after applying the technologies and the initial ones. To calculate the absolute difference (ΔCa^{2+}, ΔMg^{2+}, ΔNa^{+}, ΔK^{+}), which represents the difference between the final value (after applying the technologies) and the initial value (before application), formula (2) was used.

$$\Delta Y = Y_{after} - Y_{before} \quad (2)$$

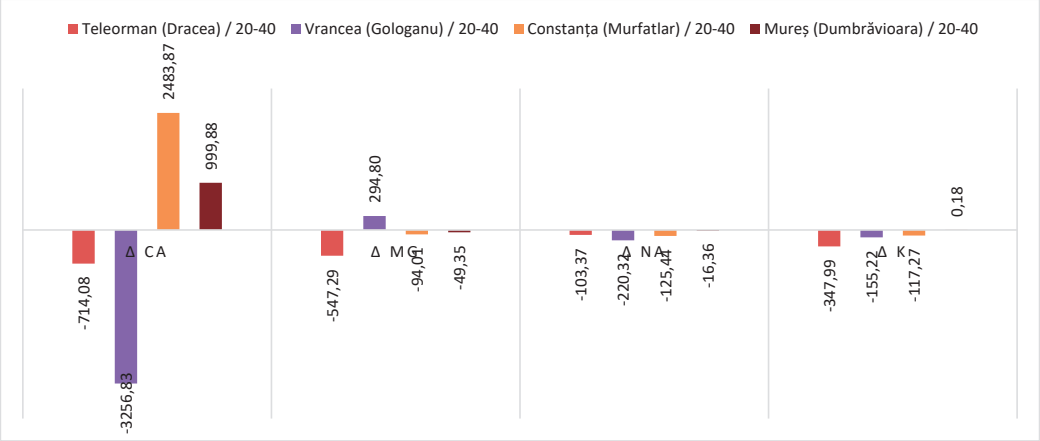
where: $Y = Ca^{2+}$, Mg^{2+}, Na^{+}, K^{+} exchangeable, in mg/kg.
Interpretation:
- $\Delta Y > 0 \rightarrow$ increase in exchangeable content (chemical enhancement / accumulation on the colloidal complex);
- $\Delta Y < 0 \rightarrow$ decrease in exchangeable reserve (biological consumption, leaching or ion exchange);
- $\Delta Y \approx 0 \rightarrow$ stability of cation exchange capacity.

Figures 6 and 7 graphically represent the evolution of exchangeable cations at the two analyzed depths.



Note: Values represent concentrations expressed in mg/kg dry soil, determined by specific extraction for the exchangeable fraction

Figure 6. Evolution of exchangeable cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}) at a depth of 0-20 cm, before and after the application of technologies



Note: Values represent concentrations expressed in mg/kg dry soil, determined by specific extraction for the exchangeable fraction

Figure 7. Evolution of exchangeable cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}) at a depth of 20–40 cm, before and after the application of technologies

Analysis of the evolution of anions and mineral nitrogen forms (Cl^-, SO_4^{2-}, NO_2^-, NO_3^-, NH_4^+)

The evolution of anions and mineral nitrogen forms is an indicator of the dynamics of nutrients in the soil solution and of active microbiological processes. These forms are directly influenced by fertilization, climatic conditions and soil biological activity.

The evolution was evaluated by calculating the absolute difference between the values determined after the application of the technologies and the initial ones.

To calculate the absolute difference (ΔCl^-, ΔSO_4^{2-}, ΔNO_2^-, ΔNO_3^-, ΔNH_4^+) formula (3) was used.

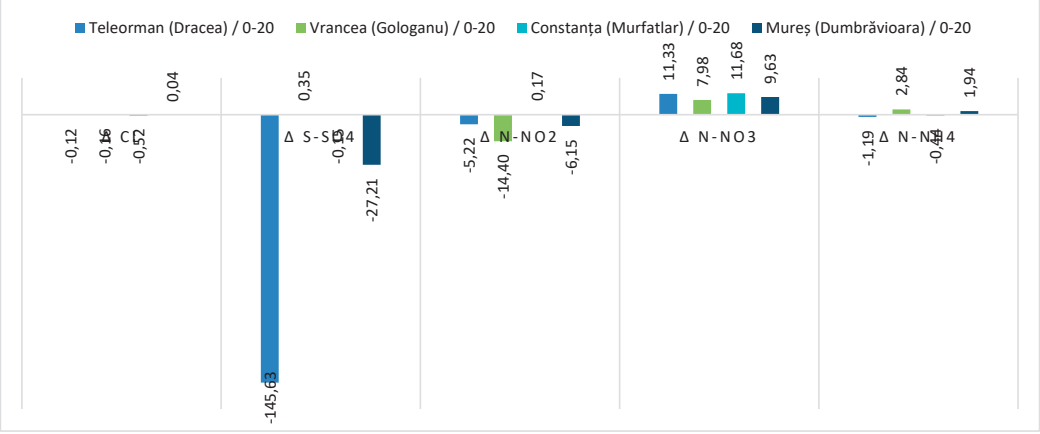
$$\Delta V = V_{after} - V_{before} \quad (3)$$

where: V = concentration of the anion or form of mineral nitrogen, in mg/kg.

Interpretation:

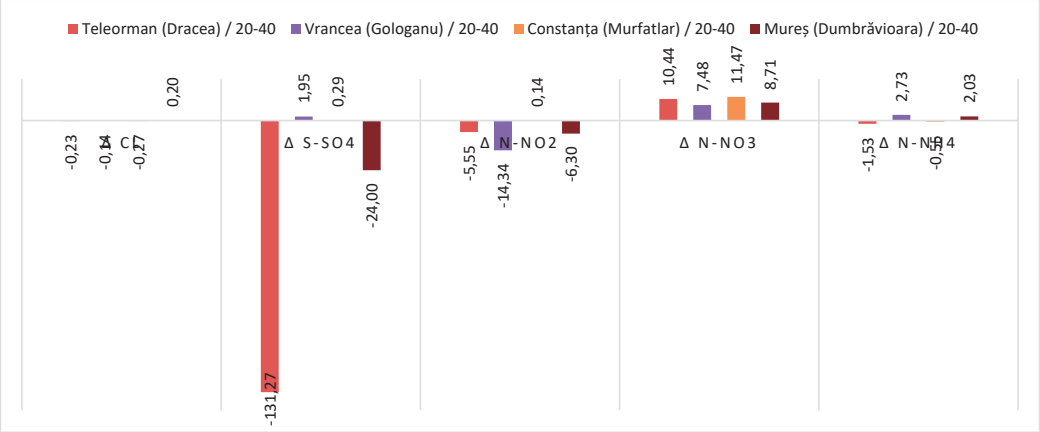
- $\Delta V > 0 \rightarrow$ accumulation in the soil solution;
- $\Delta V < 0 \rightarrow$ biological consumption, leaching or microbiological transformation;
- $\Delta V \approx 0 \rightarrow$ relative stability.

Figures 8 and 9 show the evolution of anions and mineral nitrogen forms at the two analyzed depths.



Note: Values represent concentrations determined in aqueous extract, expressed in mg/kg dry soil

Figure 8. Evolution of anions and mineral nitrogen forms in the 0-20 cm layer



Note: Values represent concentrations determined in aqueous extract, expressed in mg/kg dry soil

Figure 9. Evolution of anions and mineral nitrogen forms in the 20-40 cm layer

Depth analysis allows the identification of leaching risk, especially for NO_3^-, and the evaluation of the efficiency of fertilization management. The evolution of anions and mineral nitrogen forms is a sensitive indicator of the dynamics of the soil solution and the intensity of active biogeochemical processes in the edaphic system. These ions are predominantly found in the liquid phase of the soil, being characterized by high mobility and rapid reaction to changes in the water regime, fertilization and microbiological activity.

Analysis of soil pH evolution

The evolution of soil pH is a central element in the evaluation of changes in chemical fertility following the application of agricultural technologies. Soil reaction directly influences nutrient availability, mineral element mobility and the intensity of biological processes, being considered an integrative parameter of the soil chemical balance.

Changes in pH can cause significant changes in the accessibility of macro- and microelements to plants. Under acidification conditions, some elements can become excessively mobile, generating risks of toxicity or losses through leaching. Conversely, a tendency to alkalize can reduce the availability of some essential microelements, affecting plant nutrition. Thus, the evolution of pH indirectly reflects the efficiency of fertilization and the capacity of the soil to support the growth and development processes of crops.

In the context of assessing the sustainability of applied technologies, the analysis of pH evolution allows the identification of chemical degradation trends and the substantiation of corrective measures necessary to maintain fertility in the long term. Thus, monitoring this parameter contributes to assessing the impact of agronomic interventions on soil quality and ensuring sustainable management of soil resources.

The evolution of pH was evaluated by calculating the absolute difference between the value determined after applying the technologies and the initial value. For the calculation of the absolute difference (ΔpH) the formula (4) was used.

$$\Delta\, pH = pH_{after} - pH_{before} \quad (4)$$

Interpretation:

- Δ pH > 0 → alkalization tendency;
- Δ pH < 0 → acidification tendency;
- Δ pH ≈ 0 → stability of the soil reaction.

Figures 10 and 11 illustrate the evolution of pH at the two analyzed depths.

pH variations after the application of technologies may reflect changes in the ionic balance, determined by the input of fertilizers, nitrification processes (which generate acidity by forming H^+ ions), mineralization of organic matter or leaching of exchangeable bases (Ca^{2+}, Mg^{2+}, K^+). An increase in pH may indicate an input of basic cations or a reduction in potential acidity, contributing to the improvement of the soil reaction and the optimization of the conditions for nutrient absorption. Conversely, a

decrease in pH may signal acidification processes associated with nitrogen fertilization, sulfur oxidation or increased microbiological activity.

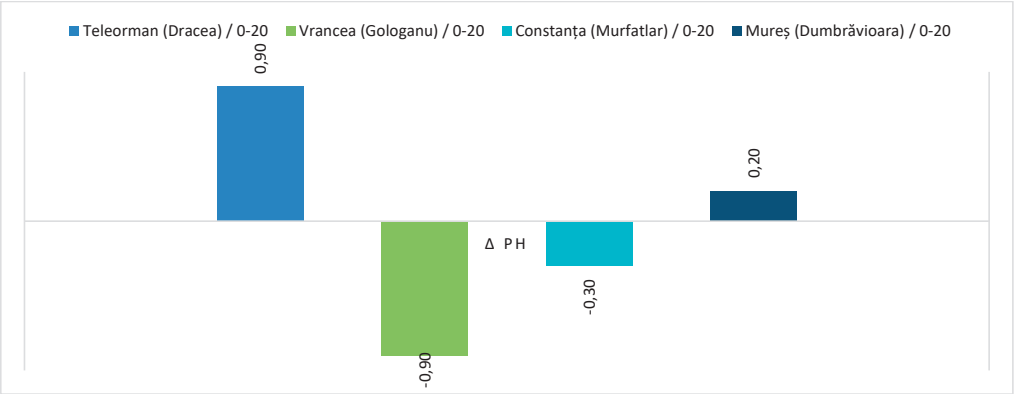


Figure 10. pH evolution in the 0–20 cm layer, before and after the application of technologies

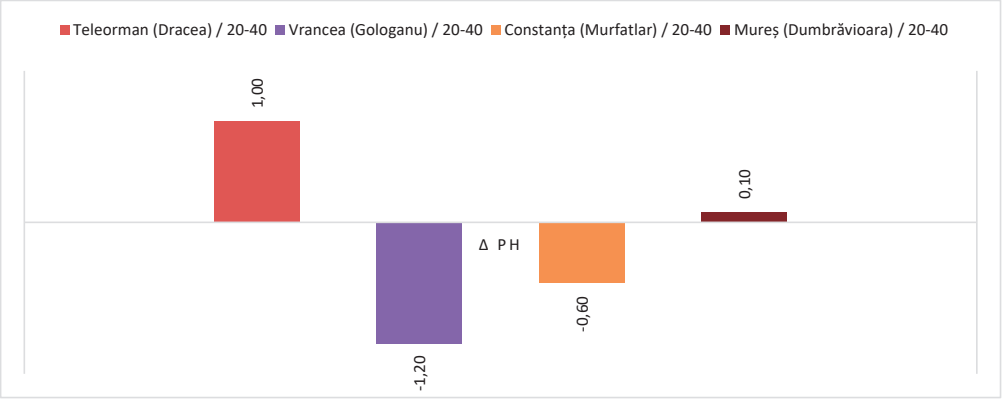


Figure 11. pH evolution in the 20–40 cm layer, before and after the application of technologies

The analysis of the evolution of pH at depth allows highlighting possible processes of acidification or alkalinization differentiated in the profile, providing information on the chemical stability of the soil and the sustainability of the applied technologies. Thus, monitoring this parameter is essential for substantiating agronomic management measures and for maintaining an optimal balance between productivity and environmental protection.

Analysis of evolution by region

A comparative analysis was conducted to evaluate the effectiveness of sustainable technologies applied in different regions, by observing soil chemical changes. The use of Δ values (the difference between element concentrations after and before the application of the technologies) allowed for a clear identification of the effects of each intervention on soil nutrients.

The main goal was to highlight which elements were stimulated, which decreased, and how they differed depending on the technology applied and local pedoclimatic conditions. Changes in the concentrations of the main elements in the soil after the application of sustainable technologies, highlighted by Δ values, are presented comparatively by region in Figure 12. The graph clearly shows the increases and decreases of the key elements (Ca, Mg, Na, K, Zn, N-NO_3^-) depending on the technology applied and the pedoclimatic context specific to each locality.

The comparative analysis by region, which highlights the elements most affected by each

technology applied, is summarized in Table 1, which shows the increases and decreases of the main elements (Ca, Mg, K, Zn, N-NO_3^-) depending on the region and type of intervention.

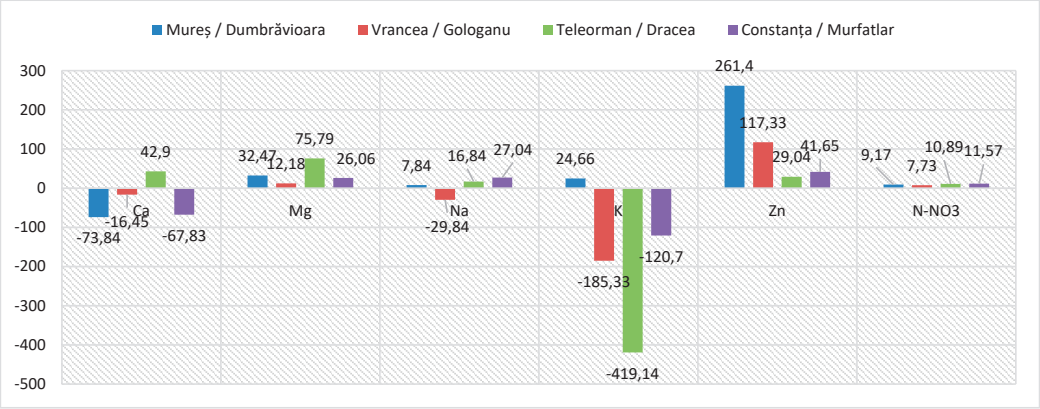


Figure 12. The effect of technologies on soil fertility: Δ variation by region

Table. 1 Regional analysis of elements influenced by sustainable technologies

Region, county	Most affected elements	Observations
Center, Mureș	Mg ↑, Zn ↑, K ↑	Deep soil loosening increased nutrient mobility and biological activity.
South-East, Vrancea	Zn ↑, K ↓, Mg ↑, N-NO_3^-↑	The biofertilizer boosted micronutrients and mineral nitrogen, but K probably decreased through plant uptake and leaching.
South, Teleorman	Ca ↑, Mg ↑, K ↓	Strip-till increased Ca and Mg, but significantly decreased K, reflecting plant uptake and water conservation.
South-East, Constanța	Mg ↑, Na ↑, K ↓, Zn ↑	Ecological interventions boosted Mg, Na and Zn, but K and Ca decreased, with minor impacts on pH and S-SO4.

The analysis by regions shows that the applied sustainable technologies consistently boosted Mg and N-NO_3^-, while K decreased in all localities. Increases or decreases of other elements (Ca, Na) depend on the type of technology and local pedoclimatic conditions. Overall, the data highlight that each technology has a specific impact on soil fertility and requires adaptation to the regional context.

CONCLUSIONS

The comparative analysis of soil characteristics before and after the application of innovative technologies highlighted positive effects on fertility and nutrient availability in the seedbed, depending on the type of intervention and the pedoclimatic conditions of each region.

Mobilization of macroelements: mechanical interventions (deep loosening, strip-till) increased the solubility of Ca and Mg, facilitating their access for plants; biofertilization stimulated the biological activity of the soil, resulting in notable increases in mineral nitrogen NO_3^- and NH_4^+).

Nitrogen regime and soil pH: all applied technologies positively influenced the soluble nitrogen content, favoring mineralization and nutrient availability. Soil pH underwent moderate variations, but sufficient to influence ion balance and micronutrient solubility.

Efficiency of technologies in pedoclimatic context: in compact soils and at risk of subsidence (Dumbravioara, Dracea), loosening and strip-till improved aeration, water infiltration and nutrient redistribution; in soils with low organic matter content and unstable structure (Gologanu), biofertilization stimulated biological activity, contributing to the mobilization of nutrients; in areas with increased water stress (Murfatlar), ecological interventions supported the increase in the

availability of nitrogen, increasing crop resilience.

The applied technologies had positive effects on soil fertility, demonstrating that combined mechanical and biological interventions can increase soil nutritional efficiency, even under variable and stressful climatic conditions.

ACKNOWLEDGEMENTS

This research was supported by project *Establishment and operationalization of a Competence Center for Soil Health and Food Safety* – CeSoH, Contract no. 760005/2022, specific project no.3, with the title: *Fertile and healthy soil through conservation and biological practices,* Code 2, financed through PNRR-III-C9-2022 – I5 (PNRR-National Recovery and Resilience Plan, C9 Support for the private sector, research, development and innovation, I5 Establishment and operationalization of Competence Centers).

REFERENCES

Hirt, H. (2020). Healthy soils for healthy plants for healthy humans: How beneficial microbes in the soil, food and gut are interconnected and how agriculture can contribute to human health. *Science & Society, EMBO reports* 21: e51069.

Jităreanu, G., Ailincăi, C., Alda, S., Bogdan, I., Ciontu, C., Manea, D., Penescu, A., Rurac, M., Rusu, T., Țopa, D., Moraru, P., I., Pop, A., I., Dobre, M., Calistru, A., E., (2020). *Agrotechnical Treaty*. Iasi, RO: Ion Ionescu de la Brad Publishing House.

Marin, E., Manea, D. (2024). Design and optimization of an chisel-type active body intended for soil work equipment without turning the furrow. *Scientific Papers. Series A. Agronomy, Vol. LXVII, No. 1*. 145 – 150.

Marin, E., Manea, D., Gheorghe, G.V., Mateescu, M., Bălțatu, C., Cismaru, E.M., Dumitru, D.N. (2023). Research on the development of a technical equipment for the incorporation into the arable substrate of a biofertilizer formulated based on soil beneficial microorganisms. *ISB – INMA TEH' 2023 Internațional Symposium Proceedings*. 366 – 373.

Popescu, E., Nenciu, F., Vladut, V. (2022). A new strategic approach used for the regeneration of soil fertility, in order to improve the productivity in ecological systems. *Sci. Pap.-Ser. E-Land Reclam. Earth Obs. Surv. Environ. Eng. 11*. 277–284

Romaneckas, K. (2022). Sustainable Tillage and Sowing Technologies. *Agronomy, 12*, 2467.

Vlăduțoiu, L., C., Marin, E., Lateș, D., Manea, D., Persu, C. (2025). Research on the use of innovative ecological technology with ploughing, equipped with rippers bodies. *Acta Marisiensis. Seria Technologica Vol. 22 (XXXIX)* no. 1, 2025. 43-50.

Vlădutoiu, L.C., Marin, E., Nenciu, F., Lates, D., Persu, I.C, Cristea. M., Manea, D. (2025). Performance Assessment of a Vibratory-Enhanced Plowing System for Improved Energy Efficiency and Tillage Quality on Compacted Soils. *AgriEngineering, 7*(9), 304.

Wuddivira, M., N., Camps-Roach, G. (2007). Effects of organic matter and calcium on soilstructural stability. *European Journal of Soil Science, 58*. 722–727.

Project Establishment and operationalization of a Competence Center for Soil Health and Food Safety – CeSoH, (n.d). Retrieved from https://www.cesoh.ro/