Research Journal of Agricultural Science, 57 (4), 2025; ISSN: 2668-926X;

http://doi.org/10.59463/RJAS.2025.4.30

# SUSTAINABLE AGRICULTURAL TECHNOLOGIES AND PRESERVATION OF SOIL FERTILITY IN PEDOCLIMATIC CONDITIONS IN GĂTAIA, TIMIȘ COUNTY

**Casiana MIHUȚ, Ion HARCĂU, Aurelia MIHUȚ, Daniel POPA, Anișoara DUMA-COPCEA**
***[1]University of Life Sciences "King Mihai I" from Timișoara, 300645, 119 Calea Aradului, Romania, Phone: +40256277001, Fax:+40256200296***
*Corresponding author: daniel_popa@usvt.ro*

***Abstract.*** *The study carried out in the locality of Gătaia, Timiş County" highlights the differences between traditional and sustainable agricultural systems applied in western Romania. The research was conducted using field observations and data collected from a local farm in Gătaia, emphasizing the relationships between natural conditions, soil types, and agricultural management practices. Conventional systems rely on intensive soil disturbance, frequent ploughing, and synthetic inputs, while conservation technologies focus on minimal tillage, surface residue preservation, and balanced fertilization. Results show that conservation practices improve soil structure, reduce compaction, and increase water retention capacity. The main soil types identified within the area were Chernozems, Eutric Cambisols, and Vertisols, all influenced by specific geomorphological and climatic conditions. The climatic regime is temperate continental, with mean annual temperatures of 10.9°C and precipitation between 600–700 mm, ensuring favorable conditions for cereals, sunflower, and maize. The research confirms that adopting conservation tillage in the Gătaia area contributes to sustainable land use, better soil fertility, and environmental protection. Furthermore, this system supports long-term productivity and resilience to climate variability. The obtained results can serve as a reference for the implementation of sustainable agricultural technologies in similar agroecosystems in the western part of Romania. In the context of climate change, the application of conservative technologies becomes a viable solution for the sustainability of agroecosystems in the south of Timiș County.*

***Keywords****: : Conservation tillage; Conventional agriculture; Soil fertility; Sustainable management; Gătaia; Timiș County; Agricultural systems.*

## INTRODUCTION

Sustainable agriculture is one of the most important development directions of the 21st century, being essential for maintaining the balance between agricultural productivity, conservation of natural resources and adaptation to climate change. According to the Food and Agriculture Organization (FAO, 2021), conservative agricultural practices ensure soil and water protection, reducing erosion, nutrient losses, and physical land degradation. In Europe, these principles are promoted through the Common Agricultural Policy and the Farm to Fork Strategy, which encourage the transition to low-environmental impact farming systems (EUROPEAN COMMISSION, 2023; HAU & JOARIS, 1999).

Numerous international studies emphasize that conservative agriculture systems improve soil structure, increase water infiltration, and increase energy and nutrient use efficiency (SHELTON ET AL., 1994; BASCH ET AL., 2008; SIMOTA, 2008; VLĂDUȚ ET AL., 2024). In the same sense, SALONTAI (2007) and GRAD ET AL. (2014) have demonstrated that the application of minimum tillage contributes to increasing the resilience of agricultural systems and reducing operating costs. Studies conducted in regions with continental climates (SZABÓ & PEPÓ, 2005; TÓTH ET AL., 2016) confirm that these technologies ensure better stability of agricultural yields and a favorable balance between the physical and biological components of the soil.

In Romania, concerns for the implementation of conservation systems have intensified in the last three decades, in the context of accentuated soil degradation and decreased humus content. The first notable research in the field was carried out by GUȘ AND TIANU (1991), DUMITRU ET AL. (1999, 2000, 2005) and FLOREA (2003), who analyzed the effects of reduced tillage on the physical and water properties of the soil. Subsequently, FLOREA and Ignat (2007) and GHEORGHIȚĂ (2006) highlighted the fact that sustainable systems contribute to maintaining cationic exchange capacity and preserving soil fertility in the long term.

Numerous Romani authors (SALA, 2002; RIFLE, 2002; ȚĂRĂU & LUCA, 2002; IONESCU, 2004; STĂNILĂ, 2006; MORARU ET AL., 2010; BUCUR, 2019; DUMA-COPCEA ET AL., 2022, 2024) stressed the importance of adapting agricultural practices to the pedo-climatic conditions specific to each region. In the west of the country, the works of MIHUȚ ET AL. (2018, 2021), MIRCOV ET AL. (2021) and CASIANA MIHUȚ ET AL. (2022) demonstrated that minimum tillage systems reduce soil compaction and water loss while maintaining intensive biological activity and stable aggregate structure.

At the regional level, the pedo-climatic conditions in the Gătaia area (Timiș County) favor the application of conservation technologies, due to the flat relief, clay texture and moderate rainfall regime (DUMA-COPCEA ET AL., 2022; DUMA-COPCEA ET AL., 2024). The dominant soils – chernozems, preluvosols and vertisols – have a high productive potential, but are vulnerable to compaction and loss of organic matter. The application of minimum tillage (8–10 cm) and the maintenance of plant debris on the surface determine the improvement of the apparent density, the increase of the infiltration rate and the preservation of soil moisture (GUȘ ET AL., 2003; RURAC ET AL., 2021; LEAH, 2013).

Also, the recent research of VLĂDUȚ ET AL. (2024) and DUMITRU CRISTINEL ET AL. (2023) shows that conservative practices contribute to reducing the carbon footprint of agriculture and making energy consumption more efficient. In areas such as Gătaia, where water resources are limited and summers are dry, these technologies have a major impact on the stability of wheat, corn, sunflower and soybean productions. Therefore, the adoption of conservation agriculture systems is an essential direction for ensuring the sustainability of agroecosystems and food security in the South-West Plain of Romania.

The purpose of the paper is to comparatively analyze the conventional and conservative technologies applied in the Gătaia area, from the perspective of natural conditions, soil types, climate regime and implications on the fertility and sustainability of agroecosystems. The specific objectives include: characterization of the physical-geographical framework of Gătaia locality; identification and description of soil types; analysis of the influence of climatic factors on the soil; assessment of the impact of technologies on edaphic and ecological properties.

The paper has an applicative character and aims to scientifically substantiate the decisions on the adoption of sustainable agricultural systems in the south of Timiș County, with emphasis on the relationship between the type of work, the conservation of soil resources and the maintenance of stable productions in variable climatic conditions.

## MATERIAL AND METHODS

For this work, field data and information provided by a farm located in the Gătaia area, Timiș county, were used.

The purpose of the research is the comparative analysis between conventional and conservative technological systems, in the context of local natural conditions.

The data collected included observations on climate regime, soil types, agricultural land use and technologies applied to wheat, maize, sunflower and rapeseed crops.

The methodology was based on the monographic method, direct observation, comparative analysis and correlation of pedological and climatic parameters. Information from soil maps, documents of the Office of Pedological and Agrochemical Studies Timișoara, as well as climatic data obtained from the Timișoara meteorological station were used.

The parameters analyzed include: average monthly and annual temperature (°C), precipitation (mm), soil types and subtypes (according to SRTS, 2012), soil reaction (pH), humus content, drainage regime and texture.

The comparative assessment of agricultural technologies was carried out by interpreting the physicochemical properties and the degree of soil damage of processes such as compaction, water stagnation and organic matter reduction.

The results were presented tabular and graphic, following the correlation between natural factors and the efficiency of the work systems.

**RESULTS AND DISCUSSIONS**

1. Physical-geographical framework

Gătaia is located in the south of Timiș County, in the Timiș Plain, at the contact with the Pogăniș Piedmont, with an average altitude of 108 m. The relief is slightly veiled, specific to the digressive plains of the Bârzava River. The total administrative area is 14,923 ha, of which over 70% is agricultural land (MIRCOV ET AL., 2021).

The geographical positioning favors the practice of mechanized agriculture, but the soils present a significant pedological variability, being influenced by the processes of glelation, stagnation and vertisolization. These particularities require an adapted use and a correct selection of agricultural technologies.

2. Climatic conditions

The climate is temperate-continental, with Mediterranean influences, characterized by mild winters and hot summers. The average annual temperature is 10.9°C, with average values of 21.6°C in July and -1.2°C in January. Average annual rainfall varies between 600–700 mm, with maximums in May–June.

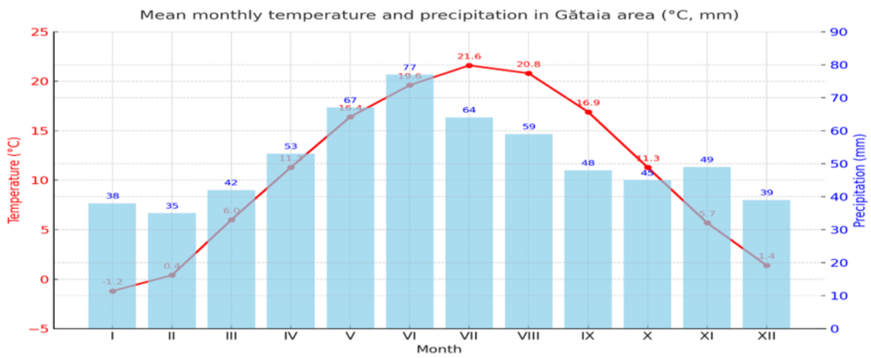


Figure 1. Mean monthly temperature and precipitation in Gătaia area (°C, mm)
*(The average temperatures show an annual amplitude of 22.8°C, characteristic of the southern Banat plain areas.)*

Research Journal of Agricultural Science, 57 (4), 2025; ISSN: 2668-926X;
http://doi.org/10.59463/RJAS.2025.4.30

3. Soil characterization

The diversity of soils in the Gătaia area is determined by geological and water peculiarities. According to the SRTS classification (2012), the following soil classes and types predominate on the territory of the locality (table 1.).

*Table 1.*

Main soil types identified in Gătaia area (SRTS, 2012)

| **Class** | **Type** | **Subtype** |
|---|---|---|
| Protisols (PRO) | Fluvisols | gleyic, vertic |
| Cernisoil (CER) | Chernozem | haplic, argic |
| Cambisols (CAM) | Eutric cambisol | mollic, gleyic |
| Luvisols (LUV) | Haplic luvisol | mollic, stagnic, vertic |
| Vertisols (VER) | Typic vertisols | stagnic, gleyic |

The predominant texture is clayey, with a weak alkaline reaction (pH 7.4–8.0). The humus content varies between 2.5–3.5%, indicating moderate natural fertility. In the depression areas, poor drainage favors the appearance of hydromorphic and gleic soils.

4. Comparative technological systems

A number of soil parameters in the two systems were compared, the data are presented in figures 1, 2, 3, 4, 5 and 6.

As for the **soil mobilization depth**, Figure 1 shows a soil working depth of 25–30 cm in the conventional system, compared to only 8–10 cm in the conservation system. Thus, deep works favor the rapid aeration and mineralization of organic matter, but lead to water losses through evaporation and fragmentation of the soil structure.

On the other hand, the conservative system determines the maintenance of stable aggregates, the reduction of compaction and erosion and energy savings. However, there are also limitations, namely, in the first years, the surface layer may be colder and the seeds may germinate more slowly, especially in cold springs.

In the Gătaia area, where chernozems and preluvosoils predominate, reducing the working depth is beneficial because the soils have good structure and natural drainage, and moisture is preserved more efficiently in conditions of frequent drought.

Conventional system

Conservation system

Research Journal of Agricultural Science, 57 (4), 2025; ISSN: 2668-926X;
http://doi.org/10.59463/RJAS.2025.4.30

**Organic residues** from the soil surface play an important role in maintaining soil moisture and humus content. In the conventional system (Figure 2), plant debris is less than 10%, compared to 30–60% found in the conservative system.

Thus, keeping plant debris on the surface protects the soil against wind and water erosion, reduces thermal amplitude and maintains high biological activity. It has a number of advantages, such as: increasing organic matter content and biological porosity, reducing evapotranspiration. However, there are also limitations, as there is a higher risk of diseases and pests developing in untreated plant residues, which requires careful management of crop rotation.

For the Gătaia area, where summers are hot and dry, covering the soil with plant debris is essential for water conservation and the formation of aggregate structure.

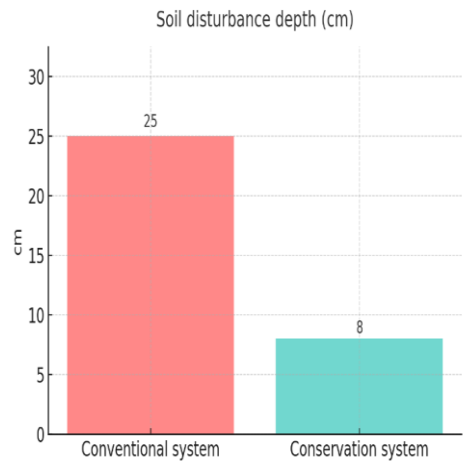

Figure 2. Soil disturbance depth, in cm

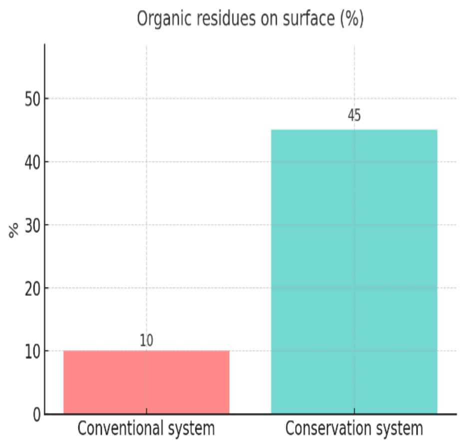

Figure 3. Organic residues on surface, %

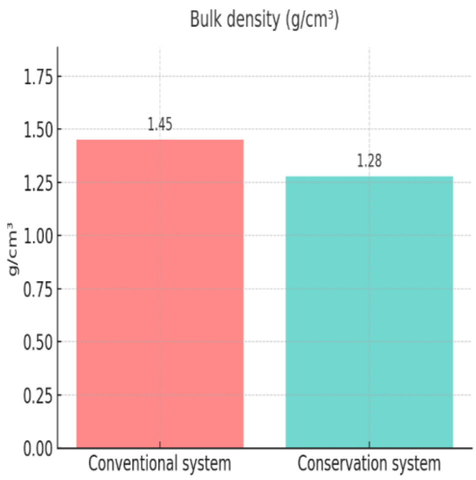

Figure 4. Bulk density, g/cm³

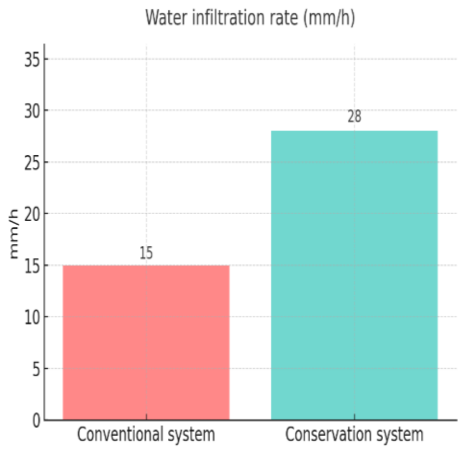

Figure 5. Water infiltration rate, mm/h

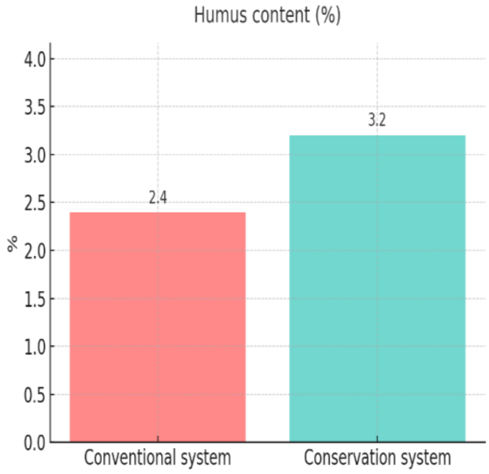


Figure 6. Humus content, %

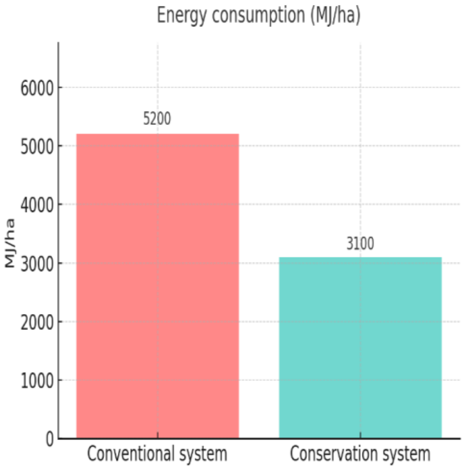


Figure 7. Energy consumption, MJ/ha

The **apparent density of the soil (g/cm³)** is influenced by the applied agricultural system (Figure 3). The DA values decrease from 1.45 g/cm³ in the conventional system to 1.28 g/cm³ in the conservative system. Lower DA values indicate good soil structuring, more porous soils with better aeration and water infiltration. This helps the development of microorganisms and plants, the roots penetrate more easily, and aerobic microorganisms intensify their activity. There are limitations, as far as clay (or heavy) soils are concerned, not doing deep work can lead to the formation of a compact layer (hardpan) over time.

In the predominantly clayey soils of the Gătaia area, with a relatively stable structure, the preservation system reduces compaction and supports a favorable balance between water and air in the soil.

**Water infiltration rate (mm/h)** (Figure 4). It increases from 15 mm/h in the conventional system to 28 mm/h in the conservative system. Thus, soils that are biologically loosened and covered with plant debris have an increased capacity to take water from precipitation, reducing surface runoff and erosion. This favors the improvement of the useful water reserve for the plants, the reduction of puddle losses and the washing of nutrients. As limitations, at first, infiltration may be uneven in soils with abundant debris, but the system stabilizes in 2–3 years.

In the perimeter of Gătaia, where the rainfall regime is uneven, a high rate of infiltration is a major advantage for wheat, corn and sunflower crops.

**The humus content (%)** (figure 5), increases from 2.4% in the conventional system to 3.2% in the conservative system. It is known that humus is the main indicator of soil fertility, influencing cation exchange capacity, structural stability and water retention. Soil conservation has a number of advantages, increasing microbiological activity and nutrient availability (N, P, K). As limitations, the growth of humus content is a slow process, requiring the continuous application of conservative technologies.

On the soils in the Gătaia area, where the natural fertility is medium to good, humus growth through minimum tillage and mulching contributes to maintaining stable yields in variable climatic conditions.

Research Journal of Agricultural Science, 57 (4), 2025; ISSN: 2668-926X;
http://doi.org/10.59463/RJAS.2025.4.30

**Energy consumption (MJ/ha)** (figure 6), the values decrease significantly from 5200 MJ/ha in the conventional system to 3100 MJ/ha in the conservation system. The conservative system involves fewer passages with agricultural machinery and reduced fuel consumption. It has a number of advantages: lower costs, reduced $CO_2$ emissions and low carbon footprint. This system, however, requires specialized equipment (direct seeders, scarifiers) and a period of technological adaptation.

In the Gătaia area, where farms mainly use modern machinery, the adoption of minimum works can lead to considerable energy and financial savings.

The results highlight the advantages of conservative technologies, which provide an improvement in soil structure and a reduction in water losses through evaporation. At the same time, the organic matter content and microbiological activity are higher, especially due to the maintenance of plant debris on the surface.

Conventional agriculture, through deep ploughing and multiple passes with heavy machinery, leads to the compaction of the arable layer and to a decrease in porosity, affecting the aeration and water infiltration processes (DUMITRU ET AL., 1999; FLOREA, 2003). By contrast, the conservative system allows the restoration of the structure of the aggregates and increases their stability over time (GUȘ & TIANU, 1991; DUMITRU ET AL., 2005).

Compared to other agricultural areas in the Banat Plain, such as Banloc or Recaș, Gătaia has similar soil and climate conditions, but a higher degree of glaciation and stagnation, which requires careful management of soil tillage European Studies (HAU & JOARIS, 1999; SZABÓ & PEPÓ, 2005) confirms that minimal tillage reduces soil loss through erosion by 30–40% and improves water retention, an effect also observed in this study.

The results obtained at Gătaia confirm the trends reported in the international literature: soils with clay texture react favorably to conservative systems, due to increased structural stability and reduced compaction. By applying sustainable technologies, an increase in water infiltration capacity and a decrease in losses due to surface runoff are achieved, contributing to the restoration of the soil water balance.

## CONCLUSIONS

The physical-geographical conditions in the Gătaia area are favorable for the application of conservation systems, due to the flat relief, moderate climate and fertile soil types.

The comparison of the two systems highlights the fact that the soil conservation system is more advantageous in the pedo-climatic conditions of the Gătaia area.

He contributes to:

- conservation of water and organic matter;
- Reduction of erosion and compaction;
- increasing energy and economic efficiency.

Although the transition requires an adaptation of technologies and good management of plant residues, the long-term benefits, increased sustainability of the agroecosystem and resilience to climate change, are obvious.

The conservation system can be successfully implemented in other localities in the Western Plain (for example, Giera, Ciacova, Deta, Banloc, Sânmihaiu Român), where the conditions are similar:

- chernozymic or preluvosolic soils,
- moderate annual rainfall (550–600 mm),
- hot and dry summers.

Major benefits include:

- maintaining moisture in the active soil layer;
- reduction of operating costs;
- increasing the stability of agricultural productions;
- protection of the soil against physical and chemical degradation.

Conventional systems cause physical and biological degradation of the soil through intense and repeated tilling.

Conservative agriculture maintains structure, reduces compaction, promotes the accumulation of organic matter and increases water retention capacity.

In the context of climate change, the application of conservation technologies becomes a viable solution for the sustainability of agroecosystems in southern Timiş County.

The results can be used as a basis for scaling up sustainable agriculture systems at regional and national level.

## BIBLIOGRAPHY

BASCH, G.; GERAGHTY, J.; STREIT, B.; STURNY, W. (2008). No-Tillage in Europe – State of the Art, Constraints and Perspectives. WASWC Publishing, ISBN 978-974-8391-60-1.

BUCUR, GH. (2019). The reaction of field crops to conventional and conservative tillage systems. Conference "Science in the North of the Republic of Moldova", Balti, 48–52.

COCIU, A.I. (2011). Contributions to the substantiation and development of sustainable technologies based on conservative agriculture. Annals of INCDA Fundulea, 79(1): 121–129.

DUMITRU, C.; ET AL. (2023). Technology and importance of qualitative sampling of soil samples intended for agricultural crops. ISB-INMA-TEH Proceedings, Bucharest, 452–461.

DUMITRU, E.; ENACHE, R.; GUŞ, P. (1999). Residual effects of some agricultural practices on the physical state of the soil. Roprint Publishing House, Cluj.

DUMITRU, E.; NICOLAESCU, M.; ENACHE, R.; CALCIU, I. (2000). The influence of reduced tillage on soil and crop yield in Romania. 2nd Workshop on Subsoil Compaction, Godollo.

DUMITRU, E. ET AL. (2005). Soil Conservation Work Between Tradition and Perspective in Sustainable Agriculture. Estfalia Publishing House, Bucharest.

DUMA-COPCEA, A.; MATEOC-SÎRB, N.; MIHUŢ, C. (2024). Importance of economic efficiency in choosing fertiliser aggregates. RJAS, 56(2): 1–7.

DUMA-COPCEA, A. ET AL. (2022). Economic efficiency of mechanization technology of minimum works in maize. Scientific Papers, 22(1): 85–92.

***EUROPEAN COMMISSION (2023). Farm to Fork Strategy and Common Agricultural Policy. Brussels.

FLOREA, N. (2003). Degradation, protection and improvement of soils and lands. Ed. Bucharest.

FLOREA, N.; IGNAT, P. (2007). About soil quality and its evaluation. Forest Journal, 122(4): 50–55.

GHEORGHIŢĂ, N. (2006). Soil Fertility – An Outdated Notion? Soil Science, 40: 75–91.

GRAD, I.; MĂNESCU, C.; MATEOC, T.; MATEOC-SÎRB, N. (2014). Studies on the agriculture systems practiced in Romania. Scientific Papers, 14(1): 567–571.

GUŞ, P.; TIANU, A. (1991). Current and perspective systems of soil tillage in Romania. National Symposium Cluj-Napoca.

GUŞ, P.; RUSU, T.; BOGDAN, I. (2003). Conventional and Unconventional Systems of Tillage. Ed. Risoprint, Cluj-Napoca.

HAU, P.; JOARIS, A. (1999). Organic Farming in Agriculture, Environment, Rural Development. EU Commission.

IONESCU, GH. (2004). Alternative agriculture in the European Community. Romanian Agriculture, 15(8): 10–14.

LEAH, T. (2013). Sustainable management of soil resources and the implementation of conservation technologies in agriculture. Moldavian Journal of Agricultural Sciences, 101–104.

MARIN, E.; SORICA, C.; MANEA, D. (2012). The establishing of corn with soil tillage and sowing in narrow strips. Actual Tasks on Agricultural Engineering, Opatija, 231–241.

MIHUȚ, C.; DUMA-COPCEA, A.; MIHUȚ, A. (2018). Evaluation of the production capacity of agricultural land from Periam locality. Scientific Papers – Management, Economic Engineering in Agriculture, 18(1): 121–126.

MIHUȚ, C.; OKROS, A.; DUMA-COPCEA, A. (2021). Soil resources in the Banloc commune, Romania. RJAS, 53(1): 45–50.

MIHUȚ C.; CIOLAC, V.; DUMA-COPCEA, A.; OKROS, A.; SCEDEI, D. (2022). Analysis of the influence of pedogenesis factors on soil formation using modern methods. SGEM Conference Proceedings, 22(3.1): 1–6.

MIRCOV, V.D.; MIHUȚ, C.; DUDAȘ, M. (2021). Interpretation and analysis of the rainfall regime in western Romania (2015–2019). RJAS, 53(1): 61–68.

MORARU, P.I.; RUSU, T.; SOPTEREAN, M.L. (2010). Control of tillage and its effect on erosion and carbon sequestration. ProEnvironment Promediu, 3(6): 25–31.

RIFLE, I. (2002). Banat Plain. "Romanian Village" National Foundation.

RURAC, M.; ZBANCĂ, A.; BALTAG, G.; BACEAN, I.; CAZMALI, N.; BOSTAN, M. (2021). Conservation agriculture – an indispensable solution for soil conservation and adaptation to climate change. Annals of UASM Chisinau, 12(3): 85–92.

SALA, F. (2002). Farming systems. Solness Publishing House, Timișoara.

SALONTAI, AL. (2007). Considerations on sustainable agriculture in the context of global problems. Agricultural Practice and Science Journal, 3–4: 63–64.

SHELTON, D. ET AL. (1994). Water erosion, conservation tillage systems and management. MidWest Plan Service, Iowa State University, 8–11.

SIMOTA, C. (2008). Development of a GIS for soil condition management under various techniques. ICPA Bucharest Report, http://www.icpa.ro.

STĂNILĂ, S. (2006). Influence of soil conservation technologies on water erosion. Agriculture – Science and Practice, 3–4: 59–60.

SZABÓ, A.; PEPÓ, P. (2005). Effect of agrotechnical and meteorological factors on yield formation in sunflower. Növénytermelés, 54: 205–212.

ȚĂRĂU, D.; LUCA, M. (2002). Panopticon of the Banat communes from a pedological perspective. Ed. Marineasa, Timișoara.

TOP, D.; JITĂREANU, G. (2007). Influence of tillage systems on porosity categories in winter wheat crops. In: Soil compaction – processes and consequences., Risoprint Publishing House, Cluj-Napoca.

VLĂDUȚ, N.V. ET AL. (2024). Trends in the development of conservative agriculture in the context of climate change – A review. INMATEH Agricultural Engineering, 74: 980–1032.SIDLAUSSKAS, G., BERNOTAS, S., 2003 – Some factors affecting seed yield of spring oilseed rape (Brassica napus L.). Agronomy Research, 1 (2): 229-243, Lituania.