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THE EFFECTS OF SOIL TILLAGE PRACTICES ON THE PHYSICO-CHEMICAL PROPERTIES OF TYPICAL PRELUVOSOIL

Lavinia BURTAN[1], Amelia ANGHEL[1], Monica DUMITRAȘCU[1], Mihaela LUNGU[1], Marian MUȘAT[2]

[1]*National Research and Development Institute for Soil Science, Agrochemistry and Environment - ICPA Bucharest, 61 Mărăști Blvd., District 1, Bucharest, Romania*
author email: lavinia.burtan@icpa.ro; amelutu@yahoo.com; dumitrascumo@yahoo.com; mihaelalungu.icpa@gmail.com
[2]*University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Mărăști Blvd., District 1, Bucharest, Romania, author email: dr_marianmusat@yahoo.com*
;

Corresponding author email: lavinia.burtan@icpa.ro

Abstract

The paper presents the results of the physico-chemical characteristics of the typical preluvosol soil (SRTS, 2012) in the pedo-climatic conditions of Brebeni, Olt County (Romania) cultivated using two soil management systems: conventional (classical) and conservative (minimum tillage). Agrophysical profiles were made, from which soil samples were taken (physico-chemical on predetermined depths of 5-10 cm; 25-30 cm and 45-50 cm). The analyses and determinations carried out are in accordance with the standardized methodology commonly used in the ICPA Laboratories and those of the County Offices for Pedological and Agrochemical Studies. Minimum tillage technology has a positive influence on the preservation of organic matter and mobile potassium content, thus contributing to the improvement of chemical characteristics, being more favorable for soil fertility, compared to the classical (conventional) technology in which a slight increase of humus and mobile phosphorus is observed, but has disadvantages in the preservation of organic matter in the long term. On medium clay loam texture (5-10; 25-30 cm) and clay loam (45-50 cm), conservative technology (minimum tillage), improves the physical characteristics of the soil, thus, maintains a looser and porous structure on the surface, reduces compaction and improves soil permeability for water, creates a healthy environment for the development and growth of plant roots, influences the rate of water infiltration and leads to better soil aeration, these aspects are essential for soil health compared to conventional technology.

***Key words**: climate change, minimum-tillage, soil properties, typical preluvosol*

INTRODUCTION

Agricultural intensification has become a necessary evil, as it is crucial worldwide to feed a growing population and support urbanisation and economic growth. There is no magical solution to increase food production without environmental side effects (Lee et al., 2023; Poudel et al., 2024). For instance, in the past, climate change has led to significant yield drops in intensively managed croplands. Globally, under the most severe climate change scenarios, cereal crops (millet, sorghum, rice, wheat and maise) are expected to lose between 7% and 23% of their yield. Maise and rice appear to be among the most affected (Pereira et al., 2025).

Agricultural intensification is an important driver of climate change because of the increasing mechanisation and various applied practices (e.g. tillage, irrigation, short crop cycles, monocultures, heavy mechanisation) that increase greenhouse gas emissions such as carbon dioxide (CO2), methane (CH4) and nitrogen oxides (NOx). For example, in monocultures, tillage can increase greenhouse gas emissions due to increased soil organic matter mineralisation rates and aggregate breakdown. In wetland environments, herbicides, glyphosate and 2,4-Dichlorophenoxyacetic acid (2,4-D) negatively affect microbial communities and increase greenhouse gas (Cornish et al., 2024). For instance, glyphosate can persist in soil 7–60 days (Kanissery et al., 2019) while 2,4-Dichlorophenoxyacetic acid (2,4-D) can remain for 20–312 days (Islam et al., 2019). Intensive tillage frequently has adverse impact on soil physical quality and soil organic carbon stocks in temperate regions. A consequence of this has been a reduction in crop production over the years demonstrating the necessity of effective and sustainable agriculture (Ţopa et al., 2021). Conventional tillage usually involves heavy tillage practices down to 20–25 cm soil depths (Pittelkow et al., 2015); this reliable management practice has resulted in reduced soil bulk density, increased porosity, and improved weed control (Pagliai et al., 2004). Conventional tillage can also adversely affect soil structure, when the process of aggregate formation is disturbed due to destruction of aggregates (Six et al., 2002). Soil aggregates are directly affected through physical disturbance of the macroaggregates and indirectly by alteration of biological and chemical factors (Gupta Choudhury et al., 2014, Li et al., 2019, Bronick and Lal, 2005). Conservation agriculture has proved to be an excellent alternative to conventional agriculture in the long term of sustainable crop production and SOC sequestration. Maintained good physical, chemical and biological properties particularly those related to soil carbon sequestration are necessary for production sustainability (Martin et al., 2019). However, intensive soil tillage, such as the conventional ploughing (also called “inversion tillage”), can be associated to severe environmental and agronomical problems, for example to a loss of soil organic matter and soil biodiversity as well as an increase of soil erosion (Fontana et al., 2015, Lal et al., 2007, Rickson, 2015, Sanaullah et al., 2020). An alternative soil tillage practice with intermediate soil disturbance is the non-inversion tillage that refers to the possibility to loosen the soil to different depths without any inversion, a technique frequently referred to as shallow or minimum tillage (Morris et al., 2010).

MATERIALS AND METHODS

Two systems of soil tillage were experimented: conventional (classical) and conservative (minimum tillage) in Brebeni, Olt county (Romania), latitude: N: 44 53140, longitude: E: 024 41688.

1) Pedoclimatic characterization of the studied area

Most of the territory is located in the the Iminogului Plain, subunit of Boianului Plain. As forms of microrelief are encountered, microdepressions and valleys that fragment the terrace.

The average multiannual temperature is 10-11^0 C (annual average) and ranges from -1.7^0 C (monthly average) in January the coldest month of the year, to 22.1 ^{0}C in July, the warmest month. The most harmful are the temperature drops in spring, summer affecting the vegetation of plants (in May up to 3.4^0 C; in June 7.9 ^{0}C; in august 7.2^0 C; in September -1.1^0 C). The average annual rainfall is 519 mm, the poorest month in precipitation is february (25.6 mm) and the wettest is june (99.5 mm).

The territory of Brebeni commune is part of the transition zone from forest steppe to forest zone (oak floor). Woody vegetation is found mainly in forests left after deforestation as well as grassy vegetation reported in uncultivated areas, slopes, road edges. As woody species: *Quercus robur, Quercus cerris, Quercus frainetto, Prunus spinosa, Tilia sp., Acer campestre,* *Fraxinus excelsior*. In the meadow area: *Populus alba, Alnus glutinosa, Salix fragilis.* Grassy species: *Setaria viridis, Cynodon dactylon, Convolvulus arvensis, Polygonum aviculare etc.*

In the studied unit there are associations of: typical preluvosoil, molic and gleic.

2) Soil sampling

Two main soil profiles have been worked out and characterized from the morphological point of view and that of the physical and chemical characteristics, according to the Working Methodology of ICPA Bucharest (MESP, vol. I-III, 1987). Soil samples were collected on the 5-10; 25-30, and 45-50 cm depths. The analyses and determinations carried out are in accordance with the standardized methodology usually used in the ICPA Bucharest laboratories and those of the County Offices for Pedological and Agrochemical Studies.

Physical analysis:

Physical determinations: apparent density determined by etuve drying method at 105 oC (Dawi g/cm3); SR EN ISO 11272:2017; determination of water permeability (Ksat mm/h) by constant water gradient method; STAS 7184/15:1991; determination of penetration resistance (Rp Kg f/cm2) STAS 7184/-88; methods of physical soil analysis (2009); determination of total porosity (PT wi % v/V) methods of physical soil analysis (2009).

Chemical analysis: Determination of pH in aqueous suspension 1:2.5; SR 7184 13:2001; determination of humus content: wet oxidation; STAS 7184/21 82; determination of nitrogen content (Nt): Kjeldahl method; STAS 7184/2-85; determination of phosphorus content (PAL): ammonium acetate-lactate extraction; STAS 7184/19-82; determination of potassium content (KAL): acetate-lactate extraction ammonium; Stas 7184/18-80; the humus reserve was determined according to (MESP, 1987, indicator 144).

RESULTS AND DISCUSSIONS

The comparative analysis of the two technologies applied in the experimental fields was carried out, with harvesting in spring and autumn in 2024, in order to observe how the conservative technologies influence the fertility characteristics of the soil within the territorial administrative unit under study, subjected to the aridization process. The comparative analysis was carried out by averaging the values (physico-chemical), of the two sampling stages and then the results of the two applied agricultural technologies were compared.

Figure 1. U. A.T. Brebeni, (Olt County).
Main profile in minimum tillage technology and agrophysical profile in conventional technology

Soil reaction (pH). In both soil working technologies, the pH retains its tendency (moderately acidic) (Figure 2.).

The humus content (%), on the depth of 5-10 cm in the classical system is small compared to the conservative system where it is medium. On the following depths in the two systems of soil tillage the humus content is small (Figure 3.).

The total nitrogen content (Nt%) is slightly higher in the minimum tillage system compared to the classical system in the first (middle) depth, and decreases with the depth in both systems (Figure 4).

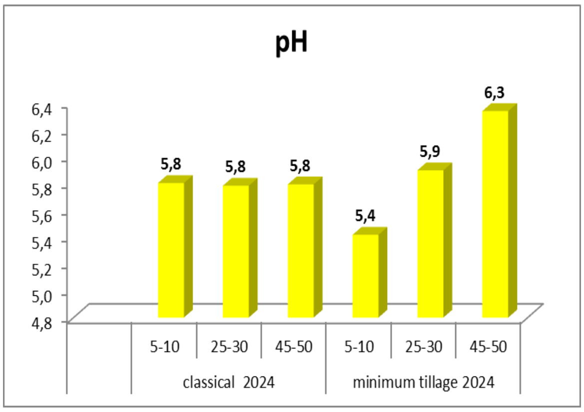

Figure 2. Influence of soil tillage on pH within U.A.T. Brebeni, Olt County

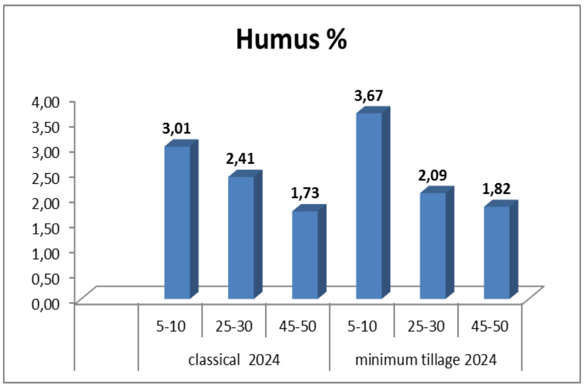

Figure 3. Influence of soil tillage on humus content within U.A.T. Brebeni, Olt County

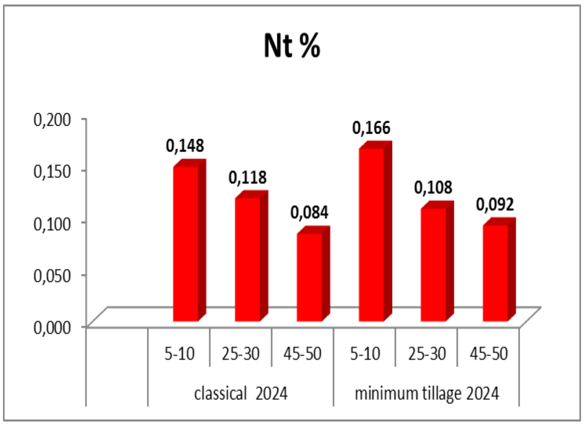

Figure 4. Influence of soil tillage on the total nitrogen content of U.A.T. Brebeni, Olt County

The total nitrogen content (Nt%) is slightly higher in the minimum tillage system compared to the classical system in the first (middle) depth, and decreases with the depth in both systems (Figure 4).

The content of mobile phosphorus (P_{AL} mg / kg) and mobile potassium (K_{AL} mg/kg) is higher in the classical experimental field on the three harvesting depths, and the content of mobile potassium is higher in the field with minimum tillage (Figures 5 and 6.).

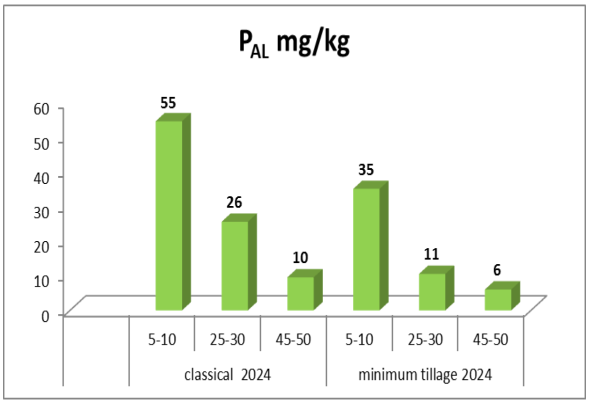

Figure 5. Influence of soil tillage on the mobile phosphorus content of U.A.T. Brebeni, Olt County

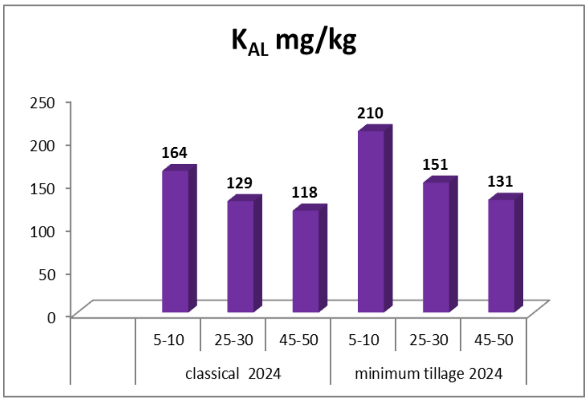

Figure 6. Influence of soil tillage on the mobile potassium content of U.A.T. Brebeni, Olt County

Humus Reserve (tonnes/ha), analyzed on the depth of 0-50 cm (Figure 7.). In classical technology, the humus reserve increases a little (159 t/ha in may 2024 and 166 t/ha in october 2024), from medium to large. In conservative technology, there is a slight decrease (middle) from 159 t/ha in may 2024 to 156 t/ha in october 2024.

Bulk density (DAwi g / cm^3) as seen in Figure 8, at the first depth of 5-10 cm, the apparent density is small (the soil is unattached) in the classical system and in the conservative one is very small (the soil is loose), suggesting a better aerated and less compacted structure.

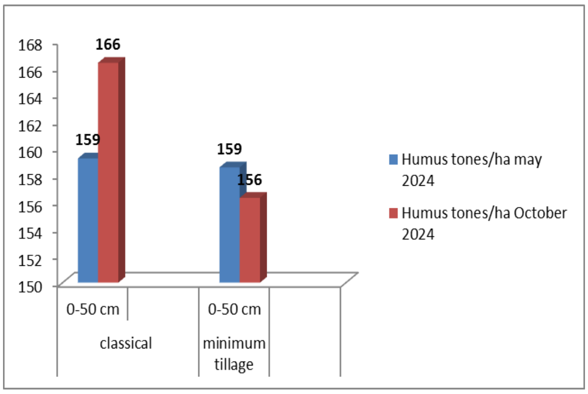

Figure 7. Influence of soil tillage on humus reserve within U. A.T. Brebeni, Olt County

At a depth of 25-30 cm, the density increases, the soil becomes poorly tamped (classical) and moderately tamped (conservative). At the last depth of harvesting soil samples (45-50 cm), the density is similar between the two technologies (moderately tamped).

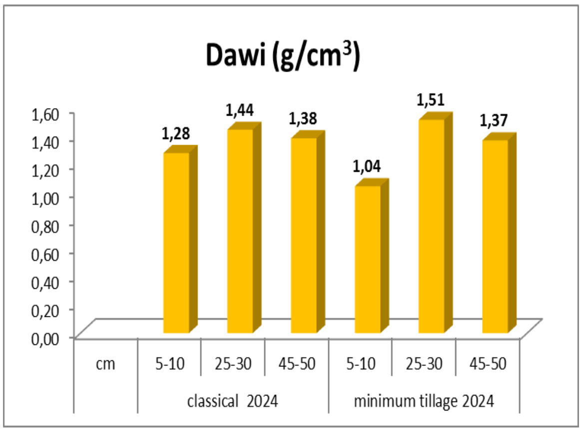

Figure 8. Influence of soil tillage on bulk density within U. A. T. Brebeni, Olt County

Penetration resistance RP (Kgf/cm2). It is observed from Figure 9, that on the depth of 5-10 cm, the penetration resistance is small in the conservative technology (14.0 Kgf/cm^2) compared to the classical (middle) technology. On the next two soil sampling depths, the penetration resistance is similar in the two technologies. Penetration resistance varies with technology and depth, reflecting how different working methods affect soil structure.

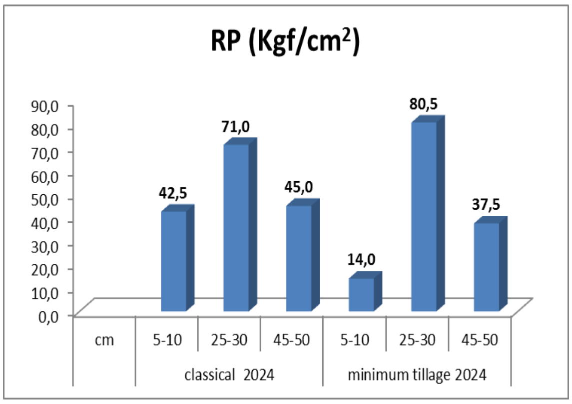

Figure 9. Influence of soil tillage on penetration resistance within U. A. T. Brebeni, Olt County

In the conservative variant, less compaction is observed on 5-10 cm, but more pronounced compaction at the following depths, which can influence the permeability and long-term soil health.

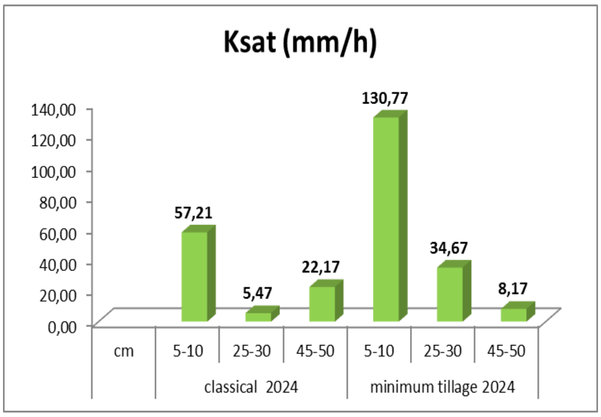

Figure 10. Influence of soil tillage on water permeability within U. A. T. Brebeni, Olt County

Water permeability Ksat (mm/h) (Figure 10.), is high in the two systems of soil works, in the first harvesting depth and on the depth of 25-30 cm (classic) the water permeability is medium compared to the minimum tillage system where it is high. On the last depth the situation is the other way around, the permeability for water is high in classical and middle in conservative. On medium clay loam texture (5-10 cm and 25-30 cm) and loamy loam on 45-50 cm naturally, it limits the permeability for water, but in the minimum tillage it improves this property.

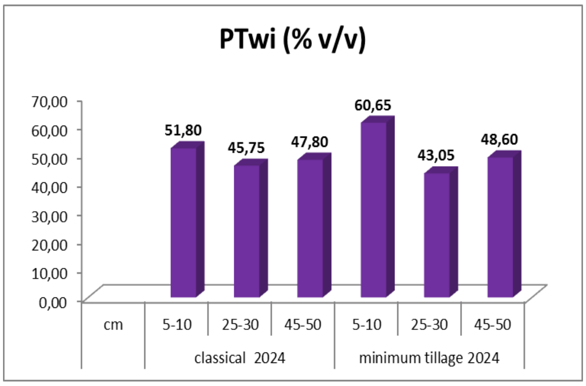

Figure 11. Influence of soil tillage on total porosity within U. A. T. Brebeni, Olt County

Total porosity, PTwi (% v/v). In the depth of 5-10 cm, the porosity is very high in the conservative (60.65%) compared to the classical (51.80%), being considered a middle value. This suggests that Conservative technology maintains or favors a more porous soil structure on the surface. At the following depths the trend is the same, a small porosity in both systems. Higher surface porosity in conservative Technology indicates a more porous structure, favoring water infiltration, airing and a more favorable environment for roots. At greater depths, porosity decreases, which is normal because the soil structure generally compacts with depth. (Figure 11.).

CONCLUSIONS

On the texture of medium clay loam (5-10; 25-30 cm) and loam loam (45-50 cm), conservative technology, improves the physical characteristics of the soil, thus, maintains a looser and porous structure on the surface, reduces compaction and improves soil permeability for water, creates a healthy environment for the development and growth of plant roots, influences the rate of water infiltration and leads to better soil aeration, these aspects are essential for soil health compared to conventional technology.

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