CHARACTERIZATION OF THE PHYSICO-CHEMICAL PROPERTIES OF THE SOIL IN THE EXPERIMENTAL POLYGON IN THE FRAMEWORK OF THE PHD THESIS "IMPACT OF CONSERVATION TILLAGE SYSTEMS AND COVER CROPS ON SOIL QUALITY INDICATORS AND YIELDS IN EZĂRENI FARM, IAȘI"

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Abstract

In this study, initial data is presented in terms of the physicochemical properties of the analyzed plot. In topographic plot 127a, the following soil quality indicators were analyzed: bulk density, soil moisture (initial and at sowing), capillary capacity, total capacity and soil pH. To determine the bulk density, undisturbed soil samples were taken, using cylinders (5 cm diameter, 5.1 cm height) with a volume of 100 cm^3 and a bottom cut at an angle of 15°. Bulk density was sampled from three points on the diagonal and four depths from 0 to 40 cm. Bulk density values ranged between 1.26 g/cm^3 and 1.36 g/cm^3. Initial moisture was determined using soil sampling probes and aluminum vials at six depths from 0-90 cm. Moisture values ranged between 14.92% and 19.82%. After sowing the winter pea crop, soil moisture was determined in both tillage systems. In the conventional system, the resulting values ranged between 17.95% and 21.90% and in the no-tillage system the values recorded ranged between 10.52 % and 17.89 %. Capillary capacity was determined in the laboratory on samples collected from the field in metal cylinders. It expresses the amount of water the soil can hold in the capillary pores. The values recorded had values ranging between 30.90% and 37.6%. Total water capacity was determined using naturally settled soil samples. This indicates the amount of water the soil holds when all soil pores are filled with water. The resulting values ranged from 34,21 % to 40,78 %. Soil pH was determined by the potentiometric method in aqueous suspension. On the 0-20 cm depth the soil reaction is neutral and on the 20-40 cm soil layer the resulting soil reaction is slightly alkaline.

Key words: bulk density, moisture, capillary capacity, total water capacity, pH

INTRODUCTION

The structure and fertility of soil determine the sustainability and fertility of cultivated land to a certain extent. As the basic unit of soil structure formation, soil aggregates have attracted much attention (Hosseini F. *et al,* 2015). The great cohesive force between soil aggregates can increase the affinity between soil particles to resist rain erosion and wind erosion (Fallahzade J. *et al*, 2020). The particle size distribution and stability of soil aggregates affect the distribution of soil pores and the transporting mode of water in soil (Li J. *et al,* 2020). The status of soil aggregates also affects the contents of soil nutrients (Liu R. *et al,* 2019).

The distribution and changes to soil aggregates can be affected by multiple factors in the soil system. For example, soil water can affect the stability of aggregates through dry-wet cycles (Kaiser M. *et al,* 2015) or freeze-thaw cycles (Dagesse D., 2011). Organic matter can combine with micro-aggregates or mineral components to form new and larger aggregates and increase the cohesion of aggregates through reducing the wetting rate of aggregates (Chenu C. *et al,* 2000). Nitrogen can increase plant-derived carbon by stimulating the growth of plants, thus promoting the formation of organic-mineral complexes (Bai T.S. *et al,* 2021). Plants can change soil aggregates by rearranging soil particles through entanglement of roots, or they can release a variety of compounds, which can cement soil particles, thus enhancing soil aggregates (Bronick C.J. *et al,* 2005). Water resources are becoming increasingly scarce due to overexploitation of water reserves and prolonged periods of drought. Regarding this aspect, conservation agriculture (CA), which includes direct seeding or direct drilling (DUS) of field crops (cereals, pulses, oilseeds, etc.) based on reduced tillage, appropriate rotation and crop

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residue management, is one of the technological packages that has proven its effectiveness in arid and semi-arid areas. Compared to conventional agriculture (CA), no-tillage (NT) practices mitigate the impact of climate change by reducing carbon emissions and conserving natural resources (Kiran Kumara T.M. *et al*, 2020). Indeed, NT practices improve chemical, physical, hydric and biochemical processes in soils (Valkama E. *et al*, 2020). They lead to homogenization of soil structure and increased structural stability after a period of adaptation, ultimately leading to improved productivity while maintaining the environment (Jat H.S. *et al*, 2019). The NT system increases soil organic matter content (SOM), saves 30-40% of labor time, labor and fossil energy, facilitates water infiltration and significantly reduces runoff and erosion (Piazza G. *et al*, 2020). Internationally, several studies have been conducted to investigate the effects of the NT system on soil physical properties in semi-arid regions.

Studies of soil hydro-physical indicators found that they were not significantly influenced by short-term tillage systems (no-tillage, minimum tillage, and conventional tillage). The soil compaction indicators as compression degree (CD) and bulk density (BD) had the lowest value in the variant with ploughing, a medium value in the variant without turning the furrow, and the minimum values in no-till (Răus L. *et al*, 2016).

Soil physical quality is influenced by soil structure, the structure of the pore system and its continuity over depth (Rabot *et al*, 2018).

A study conducted by Misbah in Ethiopia found that short-term deep tillage significantly reduced soil bulk density and penetration resistance, significantly increased soil infiltration rates, and effectively countered soil degradation (Misban A.H. *et al*, 2019). Rotary tillage can decrease soil bulk density in the 0–20 cm soil layer, increase the field’s water-holding capacity and soil porosity, and significantly enhance seedling plant height, stem diameter, leaf area, and dry weight per plant (Dong J.X. *et al*, 2021).

In his study of the Mediterranean region, Pietro believes that rototilling exposes organic matter to oxidation processes, crushing it and destroying soil aggregates (Catania P. *et al*, 2018).

Conservation tillage has significant ecological benefits, improving soil quality, enhancing water and fertilizer retention capacity, and controlling soil erosion. Currently, conservation tillage technologies centered on straw mulching and reduced/no-tillage are widely promoted in Northeast China.

No-tillage has a positive impact on soil physical properties, but the extent of change varies with time and soil texture, and the implementation of no-tillage should be combined with straw mulching and crop rotation (Blanco-Canqui H. *et al*, 2018).

Sufficient or high soil fertility supports optimal biomass production and nutrient accumulation in cover crops, which in turn have the potential to enhance soil fertility and functioning (Mortensen E.Ø. *et al*, 2021), while low soil fertility may limit cover crop growth and hence become a barrier to improving soil fertility.

Soil fertility affects plant growth and productivity directly through nutrient supply and indirectly through its influence on root growth and water supply. Interactions between soil fertility and cover crop growth may therefore occur (Blesh J., 2018). Bulk density is not an intrinsic soil property but depends on external conditions, with changes associated with a variety of factors and with various natural and anthropogenic processes (Zeng C. *et al*, 2013).

MATERIAL AND METHOD

The experiment was conducted at the Didactic Station of the from University Life Sciences of Iasi (IULS), Ezareni Farm. The experiment was located in the southern part of the farm, on a cambic chernozem, with a clay-loam texture (*figure 1*).

Figure 1 **The experimental plot – Ezareni farm**

In order to determine the bulk density, undisturbed soil samples were taken, using cylinders (5 cm diameter, 5.1 cm height) with a volume of 100 cm^3 and a bottom cut at an angle of 15°.

In each plot, samples were taken from 3 points on the diagonal at 4 depth intervals: 0– 10 cm, 10–20 cm, 20–30 cm, and 30–40 cm. The chosen samples were taken a long way from the areas' external edges in order to avoid border effects.

The soil surface from which samples were taken was cleared of plant debris and gently levelled to ensure a sufficient surface area to sample 3 replicates at each depth. Soil samples were then dried to a constant weight in a 105°C oven in the lab.

The soil's weight was noted, and the bulk density was computed using *Equation 1* (Canarache A. 1990): Bulk density (g/cm^3) = (weight of oven dried soil) / (volume of the soil) (1) The bulk density values are interpreted according to *table 1*.

Table 1

Characterisation of bulk density (according to ICPA Bucharest, 1987)

Characterisation	Values (clay-loam texture)
Extremely low	<1.05
Very low	1.06-1.18
Low	1.19-1.31
Medium	1.32-1.45
High	1.46-1.58
Very high	>1.59

In order to determine the gravimetric soil moisture regime in the experimental field, soil samples were taken in six intervals down to 90 cm depths (0–10, 10–20, 20–30, 30–50, 50–70, and 70–90 cm) with three replicates at each interval. Soil from five points were collected individually from each plot in aluminum vials.

Moisture content was determined in the laboratory by the gravimetric method, which is considered the standard method for calibrating moisture tools due to its high accuracy.

The soil resistance to penetration was determined using the Eijkelkamp penetrologger in 10 replicates on each plot to a depth of 80 cm to obtain a representative value (expressed in MPa).

Capillary water capacity was determined in the laboratory on samples collected from the field in metal cylinders.

The principle of the method consists in saturating the soil sample by capillary ascent and determining the respective moisture content.

Three soil samples are collected from the analytical unit under investigation, in a natural setting, from representative places for the same depth, using cylinders with a height of 5 cm. The soil samples were taken to the laboratory, and at the lower end the cap will be replaced with a dense metal sieve. The prepared cylinders are placed in a water bath on supports made of rods, so that the water is 3-4 mm above the bottom of the cylinder.

Capillary saturation lasts between 24-48 hours and during this time the water level remains constant. When removing the cylinder from the bath, it should be left for a short time to drain excess water from the non-capillary spaces at the bottom of the cylinder. The cylinder is wiped on the outside and then weighed.

From the cylinder the soil is emptied quantitatively into a porcelain capsule, where it is placed loosely and allowed to dry, completing the drying process in the oven until a constant value is obtained. After drying by weighing, the mass of the solid phase is obtained. In the meantime, the tare of the cylinder and accessories (Nekrasov probe, cylinders with caps and sieves, filter paper, analytical balance, porcelain capsules, oven) is determined.

Together with the wilting coefficient, the field capacity is used to calculate the irrigation norm, the watering norm, the minimum ceiling and the useful soil water capacity (*table 2).*

Table 2

Field capacity class (CC)

Interpretation	Limit	
	Weight percent	mm water/ 100 cm soil
Very small	<10	<150
Small	10-20	150-175
Medium	21-25	176-350
Large	26-30	351-400
Very large	31-40	401-500
Extremely large	>41	>501

Total water capacity was determined using soil samples in natural settlement. The principle of the method is to fully saturate the soil sample and determine the moisture content.

Soil samples collected in the same way as for the determination of the capillary capacity are placed in the water bath in such a way that the water level is 2-3 mm below the top of the cylinder, covering the cylinder with a lid to prevent evaporation. Finally, the capillary capacity is determined by weighing the value, drying in the oven and the tare of the cylinder + accessories (*table 3*).

Table 3

Total capacity classes for water (TC)

Interpretation	Limit	
	Weight percent	mm water/ 100 cm soil
Very small	<20	<360
Small	21-25	360-400
Medium	26-30	401-450
Large	31-40	451-520
Very large	41-60	521-600
Extremely large	>61	>600

The pH oscillates between 7 and 7.6 depending on the slope of the land, the humus content is 3.5%, and the nitrogen index has a value of 3.4. The pH was determined by the potentiometric method, in soil suspensions (aqueous or saline) with different ratios of soil:liquid phase (mass: volume) (*table 4*).

Table 4

Soil reaction characterization limits (ICPA Bucureşti, 1981)

pH	Soil reaction status
< 5.0	strongly acid
5.01 – 5.80	moderately acid
5.81 – 6.80	slightly acid
6.81 – 7.20	neutral
7.21 – 8.40	slightly alkaline

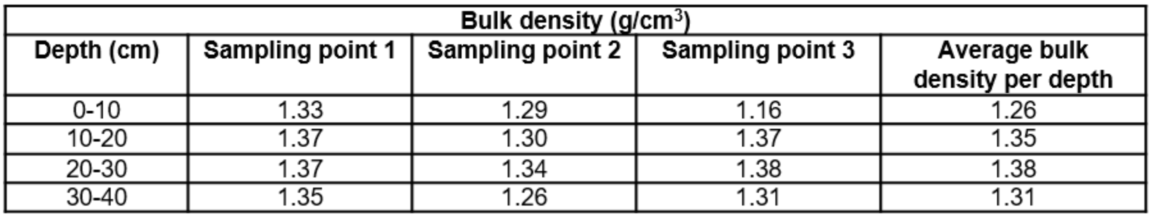
RESULTS AND DISCUSSIONS

Bulk density

In general, apparent soil density increases with depth. In the experimental polygon, bulk density values increased steadily up to a depth of 30 cm. On the 30-40 cm soil layer, the bulk density value was lower (1.31 g/cm^3) (*table 5*).

Table 5

Influence of tillage system on bulk density



Depth (cm)	Sampling point 1	Sampling point 2	Sampling point 3	Average bulk density per depth
	Bulk density (g/cm^3)			
0-10	1.33	1.29	1.16	1.26
10-20	1.37	1.30	1.37	1.35
20-30	1.37	1.34	1.38	1.38
30-40	1.35	1.26	1.31	1.31

From the data presented in *table 6*, the lowest values were recorded in the 0-10 cm surface layer, both in the initial moisture sampling and in the samples taken after sowing the forage pea crop in both tillage systems. The highest values were obtained in the 10-30 cm soil layer for all moisture sampling options.

Table 6

Influence of tillage systems on the soil moisture regime

Depth (cm)	Initial moisture	Conventional moisture	No-tillage moisture
0-10	14,92	17,95	10,52
10-20	19,82	19,54	16,88
20-30	19,39	21,58	17,89
30-50	18,11	21,90	17,13
50-70	17,06	21,31	15,40
70-90	16,50	19,93	14,49

Capillary capacity and total water capacity

Following analysis of the samples taken, the highest value of capillary capacity was recorded at a depth of 0-10 cm.

According to the ICPA Methodology, all the results recorded on the four depths fall into the very high interpretation category, with values ranging between 32.76% and 37.60%. As for the total water capacity, the highest value was also obtained on the 0-10 cm soil layer (40.78%).

According to the results, the values recorded on the four depths classifies the soil as having high total capacity (table 7).

Table 7

Capillary and total water capacity values

Depth (cm)	Capillary capacity (%)				Total capacity (%)			
	Sampling point 1	Sampling point 2	Sampling point 3	Average capillary capacity	Sampling point 1	Sampling point 2	Sampling point 3	Average total capacity
0-10	33,57	36,36	42,89	37,60	36,11	39,18	47,06	40,78
10-20	32,29	33,10	33,33	32,90	32,76	34,52	35,36	34,21
20-30	32,92	33,65	33,16	33,24	34,22	35,20	36,20	35,20
30-40	32,20	35,77	34,93	34,30	34,97	37,66	39,01	37,21

Soil pH on 0-40 cm depth

Soil pH was sampled from four depths (0-40 cm). On the 0-10 cm depth, the pH value was 7.06, which indicates a neutrally reactive soil. At 10-40 cm depth, pH values ranged between 7.35 and 7.54, indicating a slightly alkaline soil.

Table 8

pH values on soil depth 0-40 cm

Depth	Value	Soil reaction status
0-10	7.06	neutral
10-20	7.35	slightly alkaline
20-30	7.50	slightly alkaline
30-40	7.56	slightly alkaline

CONCLUSIONS

In this study, the initial state of the physico-chemical properties of the soil in the experimental polygon of the PhD work was analyzed.

Among the physical properties analyzed we list: bulk density, soil moisture, capillary capacity and total water capacity, and the chemical property analyzed was soil pH. The bulk density increased along depth, from 1.26 to 1.38 g/cm^3, resulting that the soil is optimal for plant growth.

Soil moisture was sampled in two stages, i.e. the first stage of sampling was before sowing the crop and the second stage of sampling was after sowing the autumn fodder pea crop in both tillage systems.

The values contained in the conventional system ranged between 17.95% and 21.90% and in the no-tillage system, the resulting values ranged between 10.52% and 17.89%.

The capillary capacity had values ranging from 32.76% to 37.60%.

The soil pH in the experimental polygon was also studied in four depths. In the 0-10 cm surface layer, a neutral pH was obtained, while in the 10-40 cm soil layer, the pH was in the low alkaline category.

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