INFLUENCE OF CONSERVATION TILLAGE ON THE MAIN SOIL PHYSICAL PROPERTIES OF WINTER PEA CROP IN CONDITIONS OF EZARENI FARM, IAȘI, ROMANIA

Serginho CAKPO[1], Ana URSU[1], Gabriel MIHU[1], Gerard JITĂREANU[1], Denis ȚOPA[1]

e-mail: serginhocakpo@gmail.com

Abstract

The aim of this study is to investigate the effects of different tillage on the main soil physical properties in the conditions of Ezareni Farm, Iasi, Romania. The study was conducted at the Ezareni Farm within the Didactic Station of the University of Life Sciences ,,Ion Ionescu de la Brad" Iasi. The study was carried out on a cambic chernozem soil type. Two tillage systems, the conservative or no- tillage (NT) and the conventional one (CT), have been evaluated. The soil bulk density, the soil moisture and water stable aggregates were determined for each tillage system. The bulk density was determined measuring both the soil weight and volume at sampling. These soil samples were taken from four different layers: 0-10, 10-20, 20-30 and 30-40 cm. Regarding the water stability of soil aggregates, the soil samples were also taken at different depths and the soil moisture content was evaluated. Soil samples were taken down to a depth of 90 cm. Sampling was carried out in three replicates for each depth. The no-till system had a highly significant effect on the bulk density of the soil, particularly at a depth of 10-20 cm (NT2), with 1.50 g/cm^3 being the highest value obtained. The same effect was observed for soil aggregate stability under the same treatment and at the same depth, where the highest value was 90.16%. Regarding to soil moisture, it took the second year of study to obtain a significant effect.

Key words: No-tillage, soil physical properties, winter pea, Ezareni

Today, there is great concern about food security and environmental conservation, as it is projected that food production would need to increase by at least 70% before 2050 to support the world's population. Increased demand for food has led to the use of intensive plowing systems to achieve food security (Foley J.D *et al,* 2011; Connor D.J, Mínguez M.I, 2012; Maharjan G.R *et al,* 2018). The response to this growing demand for food production is in fact based on soil conservation systems and also on crops that provide high yields and at the same time preserve the soil, the environment and biodiversity. However, intensive agricultural use is frequently associated with environmental impacts, such as contamination of the freshwater through nitrogen leaching and increased soil erosion (Maharjan G.R *et al*, 2018; Gholizadeh A., Kopackova V, 2019). It is therefore of prime importance to use tillage systems that ensure high crop yields and at the same time conserve soil, water and biodiversity (Franchini J.C *et al,* 2012).

Among the available tillage systems, conventional tillage (CT) plays an important role in the evolution of modern agriculture, contributing to high yields, physico-chemical and biological soil improvement and weed control.

In practice, CT is characterised by the complete inversion of the soil furrow by ploughing. In contrast, conservation systems include no-till (NT). These systems consist of planting crops with minimal or no soil disturbance, leaving at least 30% mulch cover (Giller K.E *et al,* 2015). Compared to CT, NT systems have gained worldwide popularity due to reduced fossil fuel consumption and improved soil carbon content, soil structure and water infiltration, which can increase farm sustainability and optimize productivity over time (Deubel A. *et al,* 2011; Ciric V. *et al,* 2012; Villamil M.B, Nafziger E.D; 2015; Zhao X. *et al,* 2017).

In Romania and abroad, research in the field of agricultural tillage systems has been directed towards finding ways to improve soil structure, reduce soil compaction, improve water and air regime, improve organic matter content, soil quality, or air quality. In order to improve the activity of microorganisms and mesoorganisms in the soil, knowledge of the changes caused by the chemicals used, the critical limits of pollution (Sin Gh., 2013; Gus P. *et al,* 2003; Ailincăi C. *et al,*

[1] Iasi University of Life Sciences, Romania

2004). In Romania, several studies have also been conducted on the influence of different tillage systems on the physical, chemical and biological properties of the soil under wheat (*Triticum aestivum*), maize (*Zea mays*), soybean (*Glycine max*), beans (*Phaseolus vulgaris L.*) or sunflower (*Helianthus annuus)*, (Țopa D. *et al*, 2010, 2011; Răus L. *et al*, 2005, Jităreanu G. *et al*, 2006, 2008, 2018), but little or none under pea (*Pisum sativum*) cultivation. We can, however, mention the researches of Marin D.I. *et al.* (2011) on the influence of tillage system on pea, wheat and maize crops in the area of Moara Domneasca - Ilfov in Romania and Bucur G. (2018) on the effect of tillage systems on certain elements and conditions of soil fertility, crop productivity in the maize for seed, pea for seed, in "Chetrosu" area, central area of Republic of Moldova.

The need to increase agricultural production in the face of population growth requires the modernisation of agriculture. Also, the need to preserve and/or improve the good condition of the soil adopts the modernisation of agriculture, but at the same time it should face these influences which are not only positive. An equation with two emerging unknowns and the subject of the study. The physical properties of the soil are influenced from one tillage system to another. To this end, it is important to understand how tillage systems influence soil physical properties.

MATERIAL AND METHOD

The study was conducted at the Ezăreni Farm within the Didactic Station of the University of Life Sciences ,,Ion Ionescu de la Brad" Iasi, Romania. The study was carried out on a cambic chernozem soil. This soil type is characterized by a loamy clay texture with loessososide deposits. Its humus content varies between 2.7 and 3.4% and has a slightly acidic pH, according to the Romanian Soil Taxonomy System (SRTS 2012).

This study consists of two successive phases. The first phase is the collection of soil samples from the two tillage systems studied, conservative and the conventional tillage systems. These samples were taken from four different soil layers: 0-10, 10-20, 20-30 and 30-40 cm. The samples were then transported to the laboratory for various analyses in the Soil Physics Department of the Research Institute for Agriculture and Environment - Iasi (ICAM).

Before sowing in the conventional system, an autumn ploughing was carried out at a depth of 30 cm with the Valtra T190 tractor and the Lemken Opal 140 reversible plough. In spring, the seedbed was prepared with a T190 tractor in aggregate with a Kompaktor and then sown.

In the conservative system, meaning without ploughing, there was no preliminary tillage and therefore seeding was done directly with the T190 tractor in aggregate with the FABIMAG FG-01 seed drill. The bulk density is defined as the weight per unit volume of absolutely dry soil with natural settlement. In our study we used steel cylinders with a height of 5.1 cm and a diameter of 5 cm. In addition to the cylinders, we also used the sampling knife and labels. Once this surface has been identified and prepared, soil samples can be taken either vertically or horizontally. Cylinders are then placed on this prepared surface and with the aid of a protective ring by tapping with a hammer, the cylinders are driven into the soil to the top edge. The ring was then removed and, using a knife, the edges of the soil in the cylinder were straightened. The ready cylinders were cleaned, labelled and placed in kits for transport to the laboratory. Soil moisture is related to the amount of rainfall, the evaporation rate, the water-holding capacity of the plants and, above all, the type of tillage system the soil is subjected to. To evaluate the soil moisture content, soil samples were taken from six soil layers to a depth of 90 cm.

This sampling was carried out in three replicates for each depth. Samples were taken at two intervals throughout the growing cycle, that is, from sowing to harvesting. Evaluation of the water stable aggregates of soil, is defined like the capacity of these aggregates to resist the action of water. Assessing the capacity of these aggregates involves several methods. The one used in our research laboratory is the Kemper and Rosenau.

RESULTS AND DISCUSSION

Bulk density

Tables 1 and *2* show the average soil bulk density values at different levels and depths after the tillage operation for the two tillage systems considered. Soil bulk density was significantly higher in NT and at different depths, particularly 10-20 cm compared to CT. Similar results also reported by (Osunbitan J.A. *et al*, 2005; Shokoofeh S.K *et al*, 2018; Burtan L. *et al*, 2020), who respectively showed in their study that the highest bulk densities were obtained with the no-till tillage system and at depths of 10-20 cm. On one hand, this difference between tillage systems is explained by the fact that, in the conventional system, ploughing is applied as a basic tillage, reducing the apparent density of the soil due to soil disturbance, while in the conservative system there are no such changes. On the other side, this result can be explained by the presence of plant residues or residues of previous crops in the conservation system, which provide protection against the dispersive action of rainfall and therefore prevent the destruction of soil aggregates. In the conventional system, there is no plant cover, the soil is carried away by rainwater, with a destructive effect on the aggregates.

It should be noted that the average bulk density values in the second year of the study show an increase in the conventional system to 1.52 g/cm^3 and are higher than in the no-till system (1.51 g/cm^3). This observation is in line with that of Bucur G. (2018) in his study. This phenomenon can be explained by the frequent passage of tractors and agricultural equipment, consecutive and repeated tillage at the same depths, which causes the soil to settle, contributing to the increase in the bulk density.

Table 1

Effect of tillage operations on Bulk Density (g/cm^3)

Parameters	Bulk density at sowing (g/cm^3)	Bulk density at harvest (g/cm^3)
CT1 (0- 10 cm)	1.13 ± 0.09 a	1.13 ± 0.05 a
CT2 (10- 20 cm)	1.24 ± 0.12 ab	1.30 ± 0.12 bc
CT3 (20-30 cm)	1.15 ± 0.09 ab	1.32 ± 0.16 bc
CT4 (30- 40 cm)	1.29 ± 0.15 bc	1.52 ± 0.16 d
NT1 (0- 10 cm)	1.25 ± 0.11 ab	1.21 ± 0.08 ab
NT2 (10- 20 cm)	1.49 ± 0.06 d	1.50 ± 0.05 d
NT3 (20-30 cm)	1.46 ± 0.07 d	1.38 ± 0.06 cd
NT4 (30- 40 cm)	1.42 ± 0.06 cd	1.42 ± 0.08 cd
P	7.91e-^{12}	5.86e-^{11}
P	***	***

a, b, c, d, e: Means for the same line with different letters are significantly different at the 5% threshold. * : P<0.05; ** : P<0.01; *** : P<0.001.

Table 2

Effect of tillage operations on Bulk Density (g/cm^3)

Parameters	Bulk density at sowing (g/cm^3)	Bulk density at harvest (g/cm^3)
CT1 (0- 10 cm)	1.29 ± 0.09 abc	1.22 ± 0.04 ab
CT2 (10- 20 cm)	1.34 ± 0.12 ad	1.34 ± 0.09 cd
CT3 (20-30 cm)	1.25 ± 0.14 ab	1.29 ± 0.06 bc
CT4 (30- 40 cm)	1.33 ± 0.13 ad	1.37 ± 0.05 ce
NT1 (0- 10 cm)	1.22 ± 0.12 a	1.16 ± 0.07 a
NT2 (10- 20 cm)	1.47 ± 0.09 d	1.45 ± 0.08 e
NT3 (20-30 cm)	1.42 ± 0.09 cd	1.39 ± 0.08 ce
NT4 (30- 40 cm)	1.41 ± 0.07 bd	1.44 ± 0.03 de
P	0.0000649	9.02e-^{14}
P	***	***

a, b, c, d, e: Means for the same line with different letters are significantly different at the 5% threshold. * : P<0.05; ** : P<0.01; *** : P<0.001.

Soil moisture

Table 3 shows the results for soil moisture at seeding in the first year of the study. These results show that there was no significant difference between the treatments evaluated (NT and CT). However, a significant difference was observed between these treatments at harvesting. And the highest soil moisture values were obtained with the conventional tillage (CT) system. This result can be explained by the low level of soil compaction and the increased space between aggregates in the conventional tillage system have led to an increase in soil water content. Knowing the high organic matter content in the no-till system and the effect of the presence of crop residues and plant cover in contributing to the increase in water retention capacity and therefore moisture, one would expect the opposite effect: to obtain high moisture in this treatment. But the results showed that the effects of reducing soil compaction on soil moisture are very high within a short period of time. This result obtained in this first year of study is in line with those obtained by (Rahimzade R., Navid H., 2011; Martins R.N., 2021). As for the results obtained in the second year (*figure 1*), we note a slight contradiction. The highest soil moisture values were registreed in the no-till system (NT). These results are consistent with those obtained by (Ussiri D.A.N., Lal R., 2009) in their study This result could be explained by the fact that crop residues were maintained on the soil surface and increased between the first and second years of our study. In fact, this condition firstly reduces evaporation and surface water runoff, then promotes soil porosity and, finally, stimulates an increase in soil water content. In addition, the regular passage of tractors and agricultural machinery on the conventional system would increase the level of soil compaction, hence the drop compared with the first year of study (*table 1*).

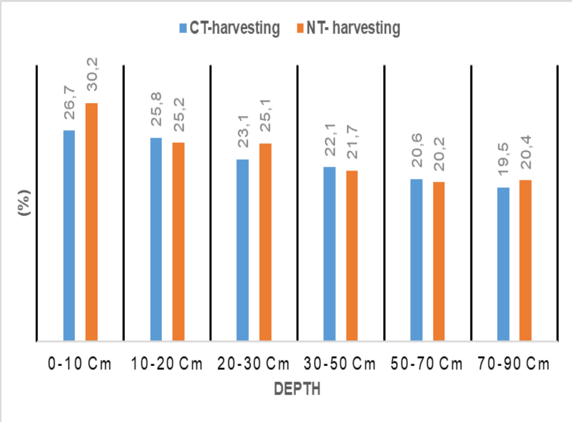

Figure 1 **Influence of conservation tillage on soil moisture**

Table 3

Effect of tillage on soil moisture (%)

Parameters	***Soil moisture at sowing* (%)**	***Soil moisture at harvesting* (%)**
CT1 (0- 10 cm)	16.55 ± 6.13 a	19.32 ±1.95 b
CT2 (10- 20 cm)	16.10 ± 3.90 a	22.63 ± 0.89 e
CT3 (20- 30 cm)	15.75 ± 1.85 a	22.10 ±1.67 de
CT4 (30- 50 cm)	16.78 ± 5.77 a	20.29 ± 1.73 bcd
CT5 (50- 70 cm)	15.75 ± 2.80 a	19.47 ± 1.47
CT6 (70- 90 cm)	15.43 ± 1.20 a	16.41 ± 1.27 a
NT1 (0- 10 cm)	15.12 ± 3.98 a	18.79 ± 1.82 b
NT2 (10- 20 cm)	15.24 ± 2.02 a	19.88 ± 1.03 bc
NT3 (20- 30 cm)	15.77 ± 1.77 a	21.52 ± 2.060 ce
NT4 (30- 50 cm)	15.55 ± 0.89 a	19.16 ±1.52 b
NT5 (50- 70 cm)	15.40 ± 1.30 a	18.44 ± 1.80 b
NT6 (70- 90 cm)	14.72 ± 0.84 a	15.78 ± 1.81 a
P	0.143	$2e^{-16}$
P		***

a, b, c, d, e: Means for the same line with different letters are significantly different at the 5% threshold. * : P<0.05; ** : P<0.01; *** : P<0.001

Water Stable Aggregates (WSA)

Results from the study of the influence of conservative (NT) and conventional (CT) systems on water stability aggregates (WSA) show a significant difference between the two systems. The highest values were obtained under NT system particularly 10-20 cm compared to CT. *(table 4).* These results are in line with those obtained by (Strudley M.W *et al*, 2008; Alvarez R., Steinbach H.S., 2009; Burtan L. *et al*, 2020).

Thus, in no-tillage soil stability increases, while tillage causes a reduction in soil aggregate size. First, this can be explained by the presence of residues from previous crops that cover the soil and are an element that favours the aggregation of elementary particles in the conservative system. Secondly, in the conventional system, the soil is without plant cover and therefore the formation of structural aggregates is more difficult and the aggregates are reduced in size due to the disturbance of the soil layers.

Table 4

Effect of tillage on Water stable aggregates (%)

Parameters	**WSA (%)**	**WSA (%)**
CT1 (0- 10 cm)	60.72 ± 0.99 a	86.07 ± 1.21 e
CT2 (10- 20 cm)	63.93 ± 1.33 b	80.89 ± 1.84 d
CT3 (20- 30 cm)	69.47 ± 2.19 c	67.89 ± 1.30 a
CT4 (30- 40 cm)	71.85 ± 1.23 cd	72.59 ± 1.29 b

NT1 (0- 10 cm)	64.62 ± 1.24 b	88.84 ± 1.19 f
NT2 (10- 20 cm)	73.80 ± 1.35 d	90.16 ± 1.66 f
NT3 (20- 30 cm)	68.90 ± 3.93 c	77.142 ± 2.72 c
NT4 (30- 40 cm)	70.13 ± 0.91 c	73.08 ± 1.59 b
P	2e-16	2e-16
P	***	***

a, b, c, d, e: Means for the same line with different letters are significantly different at the 5% threshold. * : P<0.05; ** : P<0.01; *** : P<0.001.

CONCLUSIONS

This study on the influence of conservation tillage on the main soil physical properties of the winter pea crop in the conditions of Ezareni farm, Iasi, Romania, is part of a research aimed to contribute to a better understanding of the effect of tillage systems on bulk density, moisture and soil aggregate stability in the winter pea crop. In this study the significant effect of the no-tillage system on each of these parameters was observed:

✓ From seeding to harvest, it was observed that the highest bulk density values were obtained with the conservative system. Thus, in this system, the results oscillated in the range of 1.22 g/cm^3 and 1.44 g/cm^3 at seeding and 1.21 g/cm^3 to 1.51 g/cm^3 at harvest. Another observation is that the maximum bulk density values were reached at a depth of 10-20 cm at both harvest and seeding and ranged from 1.48 to 1.51 g/cm^3.

✓ Soil moisture was influenced by the tillage systems and significantly by the conservation (no-till) system. However, it should be noted that in the first year there was no significant difference between the conservative and conventional systems.

✓ With regard to the water stability of aggregates, another physical soil property studied, a significant influence of the no-till system compared to the conventional system was also observed. The highest values were recorded mainly in the second year of the study, always with the conservative system.

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