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THE INFLUENCE OF TILLAGE SYSTEMS ON SOIL PHYSICAL PROPERTIES FOR WINTER WHEAT CROP (*Triticum aestivum* L.) AT EZARENI RESEARCH STATION

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Abstract

Tillage systems have influence on soil physical properties and have different consequences for plant growth and development. In particular, tillage systems affect yields.
The experiment was conducted at the Didactic Station of the University of Agricultural Sciences, Iasi – Ezareni Farm on a cambic mesocalcaric regraded chernozem between 2016 and 2017 for winter wheat crop.
We investigated two variants of soil tillage systems: no-till and conventional tillage regarding soil moisture and bulk density, during vegetation and harvest.
In order to determine the main physical properties such as bulk density, soil samples were collected from 10 to 10 cm down to 40 cm depth: 0-10 cm, 10-20 cm, 20-30 cm and 30-40 cm. For soil moisture the samples were collected from 6 layers as follows 0-10 cm, 10-20 cm, 20-30 cm, 30-50 cm, 50-70 cm, 70-90 cm.
The bulk density values revealed that it increased in both tillage systems and depths.
The mean bulk density showed that it registered the lowest values in no-till variant during vegetation (1.36 g/cm^3) while the highest value was registered in conventional tillage at harvest (1.55 g/cm^3).
Soil moisture showed differences along depth, growth stages and tillage systems, with higher values for the no-till variant in all periods except of the harvest, where the value was higher in conventional system compared on no-till (20.36% and 18.89% respectively).

Key words: no-tillage, tillage systems, bulk density.

Soil physical state is of particular importance for the development of crops and for obtaining high yields. Growth and development of crops, as well as water state and soil solution are strongly related to soil physical and hydrophysical properties. Therefore, the implementation of a particular tillage system must be carried out in full compliance with all aspects that can be influence or be influenced by tillage and that implies a detailed knowledge of all elements that contribute to the increase or decrease of soil fertility.

Tillage type can have both negative and positive effects on soil physical properties. Conventional tillage (CT) practices, that involve mouldboard ploughing decreases soil organic matter (Troldborg M. *et al*, 2013), and increase compaction, soil crusting, and erosion, also damaging soil biota (Kladivko E.J. 2001; Hösl R. and Strauss P., 2016). Conventional tillage on sloped areas can lead to the high soil loss rates, especially if is performed in up-slope and down-slope directions (DeLaune P.B. and Sij W.J., 2012). This practice results in high rates of erosion (e.g. Kisic I. *et al*, 2017). Therefore, there is a need for more sustainable soil management practices. On the other hand, no-tillage (NT) practices preserve soil quality and reduce soil erosion (Mwango S.B. *et al*, 2016). Conventional tillage practices may affect soil physical properties, both positively and negatively (Alvarez R., Steinbach H.S., 2009), which results in highly variable crop yields. Several studies have recorded higher crop yields under CT compared to under NT (e.g., Van den Putte A. *et al*, 2010; Tolon-Becerra A. *et al*, 2011), whereas others found no differences. Despite the relevance of the topic, very little research has been carried out on different tillage systems on soil degradation and their influence on crop production in Croatian Stagnosols (Basic S. *et al*, 2004).

The aim of the present study was to highlight the influence of tillage systems on soil physical properties in winter wheat (*Triticum aestivum* L.).

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MATERIAL AND METHOD

The experiment was established in 2014 at the Didactic Station of the University of Agricultural Sciences, Iasi – Ezareni Farm in the NE part of Romania (47°07'36" N, 27°30'45" E), 125 m altitude on a clay-loam cambic chernozem, 6.8 pH, humus content of 2.7% and average level of fertilization, no irrigation. The present study focuses mainly on the agricultural year 2016/2017.

In order to determine the influence of tillage on soil moisture and bulk density (*Bd*) for winter wheat, we investigated two tillage treatments: no-till and conventional tillage, during vegetation and harvest, between March and July 2017.

In conventional tillage, the topsoil (0-20 cm) was plowed immediately after harvesting the previous crop (soybean). Next, the disc harrow GD 3.4 was used two times on the plowed soil and the seedbed was prepared on the same day as the sowing (7th of November 2016) using the Kompactor cultivator + Valtra tractor (200 HP). In conventional tillage, the SUP 15 sowing machine was used + Goldoni tractor (50 HP). The winter wheat variety was Izvor, at a rate of 280 kg/ha.

In no-tillage, the sowing was made in the same day, using FG 150-FABIMAG seed drill, at 17.5 cm between rows using the same sowing rate as in CT. One-third of the total rate of ammonium nitrate fertilizer was incorporated under the seeds.

Bd was determined on four depth intervals: 0-10 cm, 10-20 cm, 20-30 cm and 30-40 cm, from undisturbed soil samples taken using steel rings (5 cm in diameter and 5.1 cm in height, with a total volume of 100 cm^3 per sample). The soil samples were collected from three points, diagonally from each plot, three repetitions for every depth interval.

Soil moisture was determined using the gravimetric method, on samples collected from 6 layers as follows: 0-10 cm, 10-20 cm, 20-30 cm, 30-50 cm, 50-70 cm, 70-90 cm. The samples were taken from five points, from the two variants of soil tillage systems, in three repetitions per depth range. The samples were collected in aluminum soil moisture content tins; which tare was determined in advance. Wet aluminum soil moisture content tins were weighed, then placed in the oven at 105° C, until constant weight.

The data regarding the humidity regime were correlated with the rainfall and temperature registered at the Iasi Hydrological Station, Bahlui River *(table 1).*

Table 1

Temperature and rainfall regime, Iasi (2016/2017)

Year	Month	Rainfall (mm)			Air temperature (°C)		
		Iasi	Multi-annual average of 50 years	Deviation	Iasi	Multi-annual average of 50 years	Deviation
2016	October	188.4	34.4	154.0	8.1	10.1	-2.0
	November	57.1	34.6	22.5	4.0	4.1	-0.1
	December	15.4	28.9	-13.5	0.3	-0.8	1.1
2017	January	6.7	28.9	-22.2	-4.9	-3.6	-1.3
	February	26.2	27.4	-1.2	-0.8	-1.9	1.1
	March	57.5	28.1	29.4	8.0	3.3	4.7
	April	109.8	40.3	69.5	10.1	10.1	0.0
	May	77.4	52.5	24.9	16.1	16.1	0.0
	June	51.5	75.1	-23.6	21.1	19.4	1.7
	July	41.8	69.2	-27.4	21.6	21.3	0.3
	August	66.8	57.6	9.2	21.9	20.6	1.3
	September	11.8	40.8	-29.0	17.2	16.3	0.9
Total		710.4	517.8	192.6	10.2	9.6	0.6

According to the official data from the Iasi weather station, the agricultural year 2016/2017 had an excess rainfall regime, the annual average being 192.6 mm above the multiannual average value (MAV) recorded in Iasi. Analyzing each month, relatively large deviations from the average are observed, as follows: in October 2016, there were recorded 188 l/m^2, 155 l/m^2 more than the MAV. In the winter months, December, January, February, the rainfall regime was deficient, with 36.9 l/m^2 under MAV. The spring was rich in rainfall, each of 3 months standing over the MAV, especially April, with a surplus of 69.5 l/m^2 over MAV. In June and July 2017 were droughts, with the rainfall regime below the multi-annual average of the area, 23.6 and 27.4 l/m^2 respectively, August being the only month with values higher than MAV. In September 2017, only 11.8 l/m^2 were recorded, evidently below the MAV of the region.

Regarding the temperature, the average annual data for Iasi recorded a mean of 10.2°C, the annual average being 0.6°C higher than the MAV. The average data shows that the highest deviations occurred in March (4.7 °C), June (1.7 °C) and August (1.3°C), and the lowest in October (-2.0°C) and January (-1.3°C).

The ANOVA test was used to evaluate the significance for a randomized complete block design with three replicates. Treatment means were separated by the least significance difference (LSD) test and all significant differences were reported at 5%, 1% and 0.1%.

RESULTS AND DISCUSSIONS

Regarding the *Bd* variation for the winter wheat crop *(table 2)*, it had the lowest value, as an average of the 4 analyzed depths, recorded during vegetation in the no-tillage variant (1.36 g/cm^3) and the highest value at harvest for the conventional tillage (1.54 g/cm^3).

Table 2

Tillage system influence on soil bulk density, winter wheat crop (2016/2017)

Time of sampling		Bulk density (g/cm^3)			
		Vegetation		Harvesting	
Variant		Conventional	No-till	Conventional	No-till
Depth (cm)	0 - 10 cm	1.34	1.26	1.55	1.49
	10 - 20 cm	1.38	1.36	1.59	1.45
	20 - 30 cm	1.43	1.40	1.52	1.40
	30 - 40 cm	1,.50	1.42	1.53	1.44
		c	**o**	**c**	**oo**
Mean		**1.413**	**1.360**	**1.548**	**1.445**
Differences		100	**0,053**	100	**0.103**

LSD 5%	0.051 g/cm^3	0.056 g/cm^3
LSD 1%	0.093 g/cm^3	0.102 g/cm^3
LSD 0.1%	0.207 g/cm^3	0.226 g/cm^3

Analyzing the *Bd* values for the wheat crop, they slightly increased during vegetation for both soil tillage systems. For the Plowing at 20 cm variant, the *Bd* value in the 0-10 cm layer was 1.34 g/cm^3, increasing along the depth up to 1.50 g/cm^3 in the 30-40 cm layer, compared to the no-till variant, where the values were lower. Thus, in the 0-10 cm layer, the value was 1.26 g/cm^3 and, this value increased as well with the depth, reaching 1.42 g/cm^3 on the last analyzed soil interval.

The average data for the 0-40 cm soil layer, showed a higher value of *Bd* for the conventional tillage (1.41 g/cm^3) compared to no-till where the average was 1.36 g/cm^3. These values show that the soil is poorly compacted, according to the I.C.P.A.

At wheat harvesting, it is noted that *Bd* recorded the highest value, as an average of the 4 depth intervals, for the conventional soil tillage system (1.55 g/cm^3) while in the no-till variant, the average on the four soil layers was 1.44 g/cm^3.

The statistical analysis of the results obtained as an average of the two growth stages and of the whole analyzed soil interval shows a distinct negative difference of 0.103% at harvesting, in favor of the no-till variant, while during the vegetation, it had significant negative differences compared to the control (the conventional tillage), pointing out that the differences between the two systems tillage, regarding *Bd*, increased during the vegetation season.

The repeated passing of the agricultural machinery leaded to higher *Bd* values in conventional tillage at harvest, compared to the no-till variant, due to the fact that loosen soil is easier to compact.

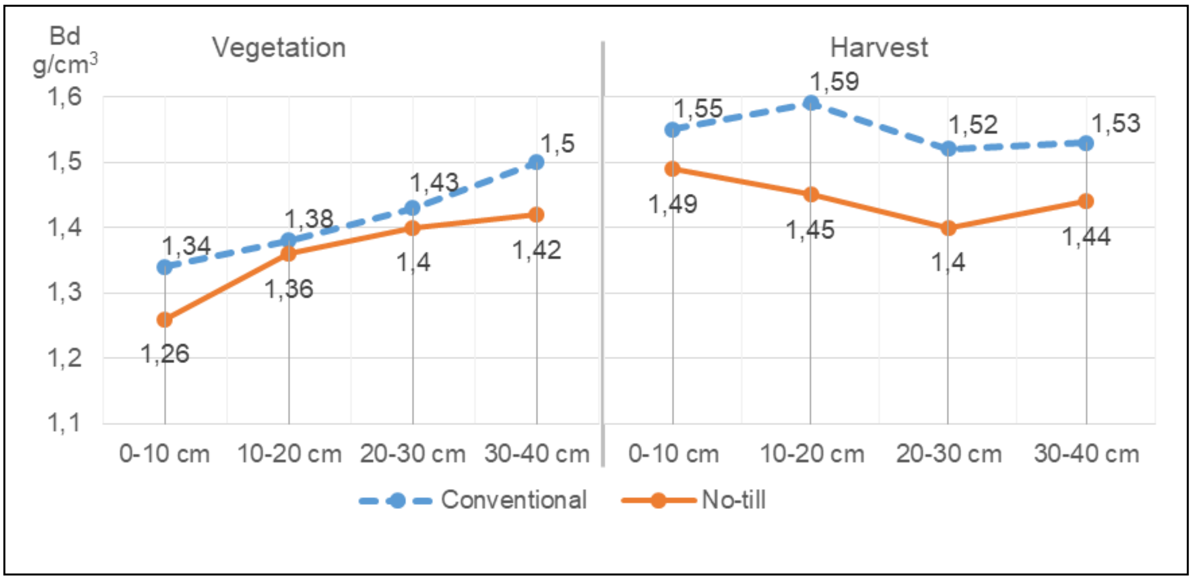

Figure 1 **– Soil bulk density evolution on depths and vegetation stages for winter wheat crop, March – June 2017**

Sample analysis highlighted that the soil moisture regime showed great variations during the vegetation period, both for conventional tillage and no-till variants *(table 3).*

Table 3

Tillage system influence on soil humidity regime, winter wheat crop (2016/2017)

Time of sampling		**Soil moisture (%)**							
		Vegetation						**Harvesting**	
Date		30th March		15th June		26th June		10th July	
Variant		Conv.	No-till	Conv.	No-till	Conv.	No-till	Conv.	No-till
Depth (cm)	0-10 cm	24.21	23.21	14.89	18.95	20.95	20.19	24.73	22.74
	10-20 cm	23.91	23.96	14.14	17.71	17.97	18.02	22.45	21.94
	20-30 cm	24.29	24.10	15.64	18.53	17.66	17.04	17.78	18.99
	30-50 cm	23.76	25.92	18.33	18.04	18.18	18.65	18.04	17.25
	50-70 cm	22.68	24.89	20.91	17.81	19.33	18.60	19.30	16.46
	70-90 cm	22.81	24.38	19.52	17.01	14.92	17.90	19.88	15.96
Mean (%U)		**23.610**	**24.410**	**17.238**	**18.008**	**18.168**	**18.400**	**20.363**	**18.890**
Differences		control	0,800 (ns)	control	0.770 (ns)	control	0.232 (ns)	control	-1.473 (ns)
		100	103.388	100	104.47	100	101.28	100	92.76
LSD 5%		1,4%		3,3%		1,5%		1,9%	
LSD 1%		2,2%		5,2%		2,4%		3%	
LSD 0.1%		3,8%		8,9%		4%		5,1%	

The average values for the vegetation period, on the 0-90 cm soil layer, revealed higher values for the no-till variant, in all three considered periods (24.41% - 30th of March, 18.01% - 15th of June and 18.40% - 26th of June) compared to the conventional tillage variant, which had noticeable lower results (23.61% - 30th of March, 17.24% - June 15th of and 18.17% - 26th of June), however statistically assured.

Analyzing the variation of the average values of samples taken on 15th June, it was noticed that the conventionally tillage variant had the lowest values of moisture (14-15%) at soil surface, 0-30 cm.

At harvest, according to the average of the analyzed soil layer (0-90 cm), a higher value of the analyzed indicator was noticed in conventional tillage (20.30%), different from previous stages of this agricultural year, when the no- till variant had higher values compared to the control. This fact is due to a higher water consumption of plants from the no-till variant, towards the end of the vegetation period, which is also highlighted by superior yields (data not presented in this paper).

For both tillage variants, higher soil moisture values were registered in the 0-20 cm layer, due to the 13.1 liters/m^2 fallen in the pre-sampling interval (2nd - 4th of July), which were retained in the upper layers.

For the no-till variant, at harvest the maximum soil moisture was in the upper layer 0-10 cm, 22.74% and it decreased along the depth (15.96% in the 70-90 cm layer).

Regarding the variation of the moisture regime along depths and growth stages, according to the applied tillage system, the values of this index oscillate between 17.24% and 23.61% for the conventional tillage and 18.01% respectively 24.41 % for the no-till variant.

The average results showed higher soil moisture during the vegetation period for the no-till variant (20.27%) and lower values for the conventional tillage (19.67%), whereas, at the harvest, the situation was reversed, with higher soil moisture for the conventional variant (20.36%) compared to the conservative one (18.89%).

The statistical analysis of the average 0-90 cm layer values in each of the three soil sampling periods indicates a variation of 0.8-0.2%, statistically unassured in the no-till variant, compared to the conventional control.

CONCLUSION

The research carried out on the cambic chernozem from the Didactic Station, regarding the influence of the tillage system on soil physical properties highlighted that:

The soil bulk density along depths and vegetation stages varied, with increased values at harvest for both tillage variants.

The data from the vegetation stage, as average along the 0-40 cm layer, showed a higher soil bulk density for the conventional tillage system (1.41 g/cm^3), compared to no-till, due to the fact that during the vegetation period, the loosen soil compacts more easily.

The average soil moisture was a higher during the vegetation period for the no-till variant (20.27%) and a lower for the conventional system variant. (19.67%).

At harvest, a higher soil moisture was recorded for the conventional variant (20.30%), different from previous stages of the agricultural year, when the no-till variant had higher values compared to the control, due to the plant water consumption at the end of the vegetation period.

When selecting the soil tillage system, it’s important to have in mind not only the immediate but also the long-term considerations that ensure the productivity of the crops.

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