THE MODIFICATION OF PHYSICAL PROPERTIES OF A CAMBIC CHERNOZEM UNDER CONVETIONAL AND CONSERVATIVE TILLAGE

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The experiment carried out during 2006-2007, was located in the East part of Romania, (47o07` N, 27o30` E), on a cambic chernozem with a clay-loamy texture and 2.7 % humus content. Each set of plots received the following treatments annually: conventional tillage: ploughed at 20 and 30 cm and unconventional tillage: disk harrow, chisel + rotary harrow, paraplow. Bulk density (BD) had the lowest values at the seeding time on 0-10 cm depth (1.12-1.20 g/cm3). The highest values have been provided by plough at 20 cm, paraplow and disc harrow variants on 20-30 cm layer. The disk harrow variant resulted in the highest values of penetration resistance (PR) on all analyzed layers (1.14 at the surface to 2.45 MPa at 40-50 cm), which would limit the ability of crop roots to expand into deep zones of moisture availability. As regards the water stable aggregates (WSA) at the sowing time, we had the biggest average value at the chisel + rotary harrow variant (77.08%) and the smallest one at disk harrow treatment (69.44%).

***Key words**: tillage, soil physical properties.*

MATERIAL AND METHOD

The experiment was initiated in 2005 and sited at the Experimental Farm of the Agricultural University of Iaşi in the East side of Romania (47^{o}07` N latitude, 27$^o$30` E longitude), on a cambic chernozem (SRTS-2003, or haplic chernozems according WRB-SR, 1998), with a clay-loamy texture, 6.8 pH units, 2.7 % humus content and a medium level of fertilization. The experimental site has an annual average temperature of 9.4^{0}C and precipitation of 587 mm. The experimental design was in a "split plots design" with three replicates. Plots covered area of 60 m^2, in a rotation of soybean, winter wheat and maize, with the current experiment in winter wheat *(Triticum aestivum L.)* followed by maize. Each set of plots received yearly the following treatments:

– **Conventional tillage**: ploughed at 20 and ploughed at 30 cm
– **Unconventional tillage**: disk harrow, chisel + rotary harrow, paraplow.

All the other agronomic practices were kept as normal and uniform for all the treatments.

The purpose of this study was to evaluate the influence of conventional and unconventional tillage systems on bulk density (BD), penetration resistance (PR), mean weight diameter (MWD) and water stable aggregates (WSA) in the areal of the Moldovian Plateau.

Soil bulk density was determined on an oven-dry basis by the core method (Blake and Hartge, 1986. Soil penetration resistance was measured after sowing, during the growing period, and at harvesting, using a digital penetrologger (Eijkelkamp equipment, The Netherlands). Ten penetration resistance measurements were taken from each plot from the soil surface to a soil depth of 50 cm. The penetrologger had a 30^0 cone and 1 cm base area.

The mean weight diameter (MWD) of the water stable aggregates from different soil samples was calculated following the method of *van Bavel (1949):* $MWD = \Sigma(X_i \times Y_i)/100$, where *yi* is the proportion of each size class by weight with respect to the total sample and *xi* is the mean diameter of the size classes (mm).

For water stable aggregates, the procedure of Kemper and Rosenau (1986) was used. The wet aggregation was calculated as the ratio of stable aggregates weight to total sample weight corrected for sand (USDA, 1998). All analyses were done in three replications.

The ANOVA procedure 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% levels.

RESULTS AND DISCUSSIONS

Soil physics was first defined as the capacity of a soil to provide a medium favorable to the development of the whole biomass, in particular plants. Nowdays, beyond the scope of agricultural production, soil physics includes our environment, i.e. constraints related to land layout as well as the protection of water quality or food health (Tessier D., 2006).

Soil bulk density is a useful parameter in the studies of soil and crop responses to machinery traffic in agriculture (Dıaz-Zorita, 2000, Yavuzcan, 2000) and is also considered to be a measure of soil quality due to its relationships with other properties (eg., porosity, soil moisture, hydraulic conductivity, etc.)

As regards soil BD in winter wheat (*Triticum aestivum L.),* this indicator had the lowest value of the seeding time at 0-10 cm depth (1.12-1.20 g/cm^3). The values increased on 10-20 cm layer, recording the greatest intensity in the disk harrow variant (1.37 g/cm^3). The highest values have been provided by plough 20 cm, paraplow and disc harrow variants on 20-30 cm layer *(table 1)*. At the growing period, the plough 30 cm and chisel + rotary harrow variant displayed the smallest values (1.22 and 1.24 g/cm^3). At harvesting, under unconventional tillage, the BD had the biggest values on all the three layers with a maximum at the disk harrow variant at 20-30 cm depth (1.55g/cm^3). BD becomes bigger once with the increasing of depth for all treatments and from sowing to harvesting. Other studies show that bulk density is increasing when reduce tillage practices are adopted (Horne et al., 1992; Franzluebbers et al., 1995; Dam et al., 2005).

The mean values of soil bulk density recorded during 2006 and 2007 show statistically significant differences between Disk harrow variant and the control treatment (in this case. an average value between all the five treatments), indicating a high compactation degree (*table 2*).

Table 1
The influence of tillage systems on bulk density in winter wheat during 2006-2007

Treatment	Depth (cm)	Bulk density (g/cm3)		
		Sowing	Growing period	Harvesting
Disk harrow	0-10	1.20	1.32	1.42
	10-20	1.37	1.46	1.47
	20-30	1.42	1.53	1.55
Paraplow	0-10	1.14	1.26	1.30
	10-20	1.28	1.40	1.42
	20-30	1.42	1.46	1.47
Chisel+ Rotary harrow	0-10	1.12	1.24	1.33
	10-20	1.23	1.35	1.37
	20-30	1.35	1.43	1.43
Plough 20 cm	0-10	1.14	1.24	1.26
	10-20	1.21	1.34	1.37
	20-30	1.40	1.43	1.45
Plough 30 cm	0-10	1.13	1.22	1.30
	10-20	1.20	1.30	1.40
	20-30	1.24	1.38	1.41

Table 2
Bulk density in winter wheat crop (2006-2007) – average values of treatment. depth and growing stages

Treatment	Bulk density (g/cm^3) – average (%)	Comparison with control variant (%)	Differences to the control variant (%)	Statistical significations
Disk harrow	1.41	105.68	0.076	**xx**
Paraplow	1.35	100.97	0.013	ns
Average	1.34	100.00	0.00	Control variant
Plough 20 cm	1.32	98.50	-0.020	ns
Chisel	1.32	98.50	-0.020	ns
Plough 30 cm	1.29	96.26	-0.050	**o**

(The control variant is the average value of the indicator for all the five treatments; ns=insignificant)

LSD 5%= 0.043 % LSD 1%= 0.063 % LSD 0.1%=0.094 %

A negative difference was also identified at the conventional tillage variant – plough at 30 cm. this treatment recording the smallest value (1.29 g/cm^3).

Penetration resistance measurements showed similar trends in the three samplings at different stages of the growing season. PR was determined when soil moisture content below 0.15 m depth was close to field capacity; measurements were averaged every 10 cm. The disk harrow variant resulted in the highest values on all the layers analyzed (1.14 MPa at the surface to 2.45 MPa at 40-50 cm), which would limit the ability of crop roots to expand into deep zones of moisture availability. As average values on 0-50 cm. the smallest penetration resistance has been observed in the conventional tilled variant, plough at 30 cm (1.38 MPa). At soil surface the smallest value was recorded in chisel + rotary harrow variant (0.60 MPa). For all the five tillage treatments PR increased in soil with depth.

Determination of soil aggregation state and of the stability of soil aggregates has been performed by using various indices but no universal prescription could be offered on which of these alternative indices is preferred (Witkowska-Walczak, Barbara, 2005). Several methods have been proposed to determine soil aggregate size distribution and stability.

The most widely approaches used to characterize soil fragments include mean weight diameter (van Bavel. 1949*),* water stable aggregates (Kemper, W.D., and R.C. Rosenau. 1986) and others.

Table 3

The evolution of mean weight diameter (mm) in winter wheat (average 2006-2007)

Treatment	Depth (cm)	MWD (mm)					
		Sowing		Vegetation		Harvesting	
Disk	0-10	4.2		4.7		5.8	
	10-20	5.2		5.5		6.3	
	20-30	5.7		6.1		6.5	
Average		5.0	o	5.4	oo	6.2	ooo
Paraplow	0-10	6.0		6.7		7.1	
	10-20	6.7		6.9		7.3	
	20-30	6.9		6.9		7.6	
Average		6.5	x	6.8	x	7.3	xx
Chisel + Rotary Harrow	0-10	5.9		6.5		7.2	
	10-20	6.6		6.9		7.5	
	20-30	6.9		7.3		7.7	
Average		6.5	x	6.9	x	7.4	xxx
Plough 20 cm	0-10	5.1		5.5		6.4	
	10-20	5.4		5.7		6.6	
	20-30	6.8		5.6		7.0	
Average		5.8	ns	5.6	o	6.7	xx
Plough 30 cm	0-10	5.1		6.4		6.9	
	10-20	5.3		6.8		7.1	
	20-30	5.6		7.0		7.3	
Average		5.3	ns	6.7	ns	7.1	ns
Control Treatment		5.8		6.3		7.0	
LSD 5%		0.6		0.5		0.2	
LSD 1 %		0.9		0.7		0.2	
LSD 0.1%		1.3		1.1		0.3	

(The control variant it is the average value of the indicator for all the five treatments; the comparisons are on columns; ns=insignificant)

The dynamics of MWD on the cambic chernozem from Iaşi for all tillage treatments is shown in *table 3*. Right after the sowing, the minimum value of this index was recorded on disk variant (5.0 mm on average), especially on 0 -10 cm layer, as consequence of the existence of aggregates with a small diameter, the highest value has been observed at the conservation tillage variant paraplow and chisel (6.5 mm). On vegetation stage, the MWD ranged from 5.4 mm to 6.9 mm. The tendency is to increase from sowing to harvesting, this phenomenon having a greater intensity on upper layers. The biggest value at harvesting has been observed at the chisel treatment (7.4 mm) with a peak on 20-30 cm layer (7.7 mm).

The water stable aggregates for all the five tillage treatments showed an increasing trend from sowing to harvesting period. Thus, at the sowing time, we had the biggest average value at the chiesel + rotary harrow variant (77.08%) and the smallest one at disk harrow treatment (69.44%), a normal value as a matter a fact. At the same period, on the layer 0-10 cm, the variant plough at 30 cm had the biggest value, because of bringing the stable aggregates from 30 cm depth simultaneously with tillage operation. On the next two layers 10-20. 20-30 cm, the values had the tendency to decrease slightly. Contrary, at the disk harrow variant, the tendency is to increase from 71.43% at 0-10 cm layer to 80.10% on 20-30 cm layer at the growing period, and from 72.30% to 84.80% at harvesting. The stability of fine aggregates depends on the amount and the stability of organic cementing agents. Arshad et al. (1999) point out that aggregates >0.25 mm were by 60% greater in no tillage than in conventional tillage at a depth of 0–5 cm. but showed no difference at depth of 12.5–20 cm.

Ghuman and Sur (2001) indicate that reduced tillage did not make any appreciable change in the aggregation status of soil compared with conventional tillage. Contrary to these results, some authors reported that the stability was smaller under reduced tillage compared to other tillage practices (Unger, 1997; Hajabbasi and Hemmat, 2000).

Table 5

WSA (%) in winter wheat (2006-2007) – average values on treatment, depth and growing levels

Treatment	Macrostructural hydrostability degree – average (%)	Comparison with control variant (%)	Differences to the control variant (%)	Significations
Chisel	79.7	103.10	2.4	xx
Paraplow	78.5	101.55	1.2	ns
Plough 30 cm	77.3	100.00	0.0	ns
Average	77.3	100.00	-	Control variant
Plough 20 cm	77.2	99.87	- 0.1	ns
Disk harrow	73.7	95.34	-3.6	ooo

(The control variant is the average value of the indicator for all the five treatments. ns=insignificant)

LSD 5%= 1.4% . LSD 1%= 2.1% LSD 0.1%= 3.1%

However, the effect of tillage system on WSA reveal a negative statistically significant difference at the disk harrow variant compared with control treatment. The chisel variant is also statistically assured, being with 2.4% bigger that the control treatment (*table 5*).

CONCLUSIONS

At harvesting, under unconventional tillage, the BD had the biggest values on all the three layers with a maximum at the disk harrow variant at 20-30 cm depth (1.55g/cm^3). BD becomes bigger once with the increasing of depth for all treatments and from sowing to harvesting. Penetration resistance measurements showed similar trends in the three samplings at different stages of the growing season. The water stable aggregates for all the five tillage treatments showed an increasing trend from sowing to harvesting period. Thus, at the sowing time, we had the biggest average value at the chiesel + rotary harrow variant (77.08%) and the smallest one at disk harrow treatment (69.44%), a normal value as a matter a fact. The effect of tillage system on WSA reveal a negative statistically significant difference at the disk harrow variant compared with control treatment. The chisel variant is also statistically assured, being with 2.4% bigger that the control treatment.

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