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THE INFLUENCE OF REDUCED TILLAGE SYSTEMS ON PHYSICAL PROPERTIES OF A CAMBIC CHERNOZEM FROM MOLDAVIAN PLATEAU

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Abstract

The experiment carried out during 2006-2007, was located in the Eastern part of Romania, (47°07` N, 27°30` E), on a cambic chernozem with a clay-loamy texture and 2.7% humus content. Bulk density (BD) had the lowest values at the seeding time on 0-10 cm depth (1.12-1.20 g/cm^3). 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 highest average value at the chisel + rotary harrow variant (77.08%) and the smallest one at disk harrow treatment (69.44%).

INTRODUCTION

Agricultural tillage practices have changed in Romania over decades. Soil conservation tillage, which intend to leave residues on the soil surface and may include reduced till (using disks or chisel plough, for example) or no-till, has become a popular practice recently, in Romania. Continuous ploughing at the same depth leads to the formation of a hard pan in the lower layers over a period of time [1, 12], which hinders the deeper penetration of roots into soil and a direct negative influence on yield. Knowing the soil structure as an essential element of soil fertility has a great importance [8], because it influences not only the physical conditions, aeration and food regime, but also the accessibility of nutrients for plants, degradation of organic material in soil and microbiological activity [13].

MATERIAL AND METHODS

The experiment was initiated in 2005 and sited at the Experimental Farm of the Agricultural University of Iasi in the Eastern side of Romania (47°07` N latitude, 27°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 replications. 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 cm and ploughed at 30 cm;

– reduced tillage: disk harrow, chisel followed by 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), and water stable aggregates (WSA) in the area of the Moldovian Plateau.

Soil bulk density was determined on an oven-dry basis by the core method [3]. Soil penetration resistance was measured after sowing, during the growing period, and at harvesting, using a digital Eijkelkamp penetrologger. 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. For water stable aggregates, the procedure of Kemper and Rosenau (1986) was used.

RESULTS AND DISCUSSION

Soil bulk density is a useful parameter in the studies of soil and crop responses to machinery traffic in agriculture [5, 15] 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 (1.55 g/cm^3). BD becomes 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 [2, 6, 4].

Table 1

The influence of tillage systems on bulk density in winter wheat crop (2006-2007)

Treatment	Depth (cm)	Bulk density (g/cm^3)		
		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%

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).

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.

The most widely approaches used to characterize soil fragments include mean weight diameter [14], water stable aggregates [11] and others.

The water stable aggregates for all the five tillage treatments showed an increasing trend from sowing to harvesting period (table 3). Thus, at the sowing time, we had the highest average value at the chisel + 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 highest value, because of bringing the stable aggregates from 30 cm depth simultaneously with tillage operation. On the next two layers 10-20 and 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. Arshad et al. (1999) point out that aggregates >0.25 mm were by 60% higher 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 [9].

However, the effect of tillage system on WSA reveal a negative statistically significant difference at the disk harrow variant compared with control treatment.

Table 3

The evolution of WSA (%) in winter wheat (average of 2006-2007)

No.	Treatment		Sowing period 2006	Growing period 2007	Harvesting 2007
1	Disk harrow	0 - 10 cm	69.58	71.43	72.30
2		10 - 20 cm	63.92	70.45	75.50
3		20 - 30 cm	74.83	80.10	84.80
Average			**69.44**	**73.99**	**77.53**
4	Paraplow	0 - 10 cm	75.42	79.90	85.10
5		10 - 20 cm	71.58	74.50	77.90
6		20 - 30 cm	74.92	81.67	85.60
Average			**73.97**	**78.69**	**82.89**
7	Chisel + rotary harrow	0 - 10 cm	79.92	82.67	85.40
8		10 - 20 cm	76.25	78.39	81.60
9		20 - 30 cm	75.08	77.45	80.91
Average			**77.08**	**79.50**	**82.64**
10	Plough 20 cm	0 - 10 cm	71.50	76.90	86.32
11		10 - 20 cm	72.17	73.68	76.34
12		20 - 30 cm	77.50	79.67	80.61
Average			**73.72**	**76.75**	**81.08**
13	Plough 30 cm	0 - 10 cm	77.50	79.83	80.59
14		10 - 20 cm	71.92	75.67	82.82
15		20 - 30 cm	73.58	75.80	77.65
Average			**74.33**	**77.10**	**80.35**

The chisel variant is also statistically assured, being with 2.4% higher that the control treatment (table 4).

Table 4

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%

CONCLUSIONS

1. The disk harrow variant resulted in the highest values on all the layers analyzed, which would limit the ability of crop roots to expand into deep zones of moisture availability.
2. BD becomes bigger once with the increasing of depth for all treatments and from sowing to harvesting.
3. At the sowing time, we have found the highest average value of WSA at the chisel + rotary harrow variant (77.08%) and the smallest one at disk harrow treatment (69.44%).

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