The Influence Of Conventional And Unconventional Tillage Systems On The Physical Properties Of A Chambic Chernozeom From The North-East Of Romania

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1. Abstract

For plant growth it is desirable to have a physical condition in which the soil is in optimal conditions, friable, where porous assemblages of aggregates permit the free movement of water and air, easy cultivation and planting, and unobstructed germination and root growth. The experiment was initiated in 2005 and sited within the Experimental Farm of the Agricultural University of Iaşi in the East part of Romania (47°07` N latitude, 27°30` E longitude), on a chambic chernozem (SRTS-2003, or haplic chernozems after WRB-SR, 1998), with a clay-loamy texture, 6.8 pH units, 2.7 % humus content and a medium level of fertilization. The dynamics of soil physical properties such as bulk density, penetration resistance, aggregate size distribution or hydric stability and how they are influenced by tillage systems are considered in this paper.

2. Introduction

Conservation tillage practices have gained considerable support by merit of their erosion control capabilities. Unconventional soil tillage, using paraplow, chisel or disk harrow instead of plough, has become a popular conservation practice in recent years in Romania. The introduction of conservation practices in productive soils could avoid or reduce soil degradation under intensive agricultural management. The objective of this work was to evaluate the effects of conventional and unconventional tillage systems on bulk density, penetration resistance, aggregate size distribution and water stable aggregates in a productive soil from northeast of Romania. Soils of Romania were classified according to their suitability for various tillage systems (Canarache, 1997), and some 50 percent of the arable area of the country was considered suitable for conservation tillage.

Soil tillage systems affect mechanical behavior of soil layers. Horn (1986, 2004) determined that soils under a long-term conservation tillage induced changes in physical properties compared with conventionally tilled soils, being more resistant and thus less susceptible to deformation.

The basic soil tillage method can involve a wide range of tillage methods from intensive to reduced cultivation systems. The state or quality of the soil to which these tillage methods are applied for maize crop management is not easily determined and excessive cultivations are often used. Changes in soil physical properties due to use of conventional or unconventional tillage, depend on several factors including differences in soil properties, weather conditions, history of management, intensity and type of tillage.

3. Methods

The experiment was initiated in 2005 and sited at the Experimental Farm of the Agricultural University of Iaşi in the East part of Romania (47°07` N latitude, 27°30` E longitude), on a chambic chernozem (SRTS-2003, or haplic chernozems after 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 "divided plots design" with three replications. Plots covered surface of 60 m^2, in a rotation of soy-bean, winter wheat and maize, with the current experiment in maize *(Zea mais)* followed by soybean. Each set of plots received yearly the following treatments:

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

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

Corn, hybrid Pioneer PR38V91 (FAO 300, or CRM 91 after the Pioneer classification), was drilled on May 4, 2006 using a SPC-6 drill machine. Distance between crop rows was 0.70 m, and plant population at harvesting was 65000 plants/ha.

Soil bulk density (BD) was determined on an oven-dry basis by the core method (Blake and Hartge, 1986). Soil penetration resistance (PR) was measured after sowing, during the growing period, and at harvesting, using a digital penetrologger (Eijkelkamp equipment, The Nederlands). 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 a 1 cm base area.

For water stable aggregates (WSA), the procedure of Kemper and Rosenau (1986) was used. Four grams of 1–2 mm air-dried aggregates were placed into sieves and wetted with sufficient distilled water to cover the soil when the sieve is at the bottom of its stroke. The sieves were allowed to raise and lower 1.3 cm, 35 times/min for 3 min (Eijkelkamp- Wet Sieving Apparatus). The remained material (stable aggregates) in the sieve was dispersed with 2g/l NaOH. 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.

For aggregate size distribution, soil samples were taken from the fields just after the sowing of maize, during the vegetation season and right after the harvesting. Following drying of the soil in the laboratory to the air-dry state, large clods (>20 mm) were broken into smaller aggregates along their natural planes of weakness by using gentle manual forces. Then the soil was sieved through a set of sieves (10, 5, 3, 1, 0.5 and 0.25 mm apertures) to obtain seven size fractions: <0.25; 0.25–0.5; 0.5–1; 1–3; 3–5, 5–10 mm and >10mm, using a sieve shaker machine AS300 from Retsch® - Germany. Weights of the aggregates remaining on each sieve were used to determine aggregate size distribution.

The ANOVA procedure was used to evaluate the significance of each tillage treatment on macrostructural hydrostability degree in a randomized complete block design with three replications. Treatment means were separated by the least significance difference (LSD) test and all significant differences were reported at the 5%, 1% and 0.1% levels.

4. Results

The dynamics of soil physical properties such as bulk density, penetration resistance, aggregate size distribution or hydric stability and how they are influenced by tillage systems are considered in this paper. Soil bulk density (BD) is probably the most frequently measured soil quality parameter in tillage experiments (Rasmussen, 1999).

Several authors found greater soil bulk density under conservation tillage than conventional tillage (Hammel, 1989; Ferreras et al., 2000), while others did not find differences (Chang and Lindwall, 1989), or obtained lower values of bulk density under soils with a residue layer on.

The dynamics of bulk density on the chambic chernozem from Iasi for all tillage treatments is shown in *table 1*. The BD increased with time and depth after tillage for all five tillage treatments as the soil gradually get compacted under the influence of rainfall and particle resettlement. In the 0-10 cm layer the biggest value of BD at emergence time was observed in the disk harrow variant (1.17 g/cm^3) while the lowest value was recorded in chisel + rotary harrow variant (1.09 g/cm^3) consequence of loosening by rotary harrow during seedbed preparation.

Table 1 Bulk density under conventional and unconventional tillage systems

Tillage	Depth (cm)	Bulk density (g/cm^3)		
		Emergence	**Vegetation**	**Harvesting**
Disk harrow	0-10	1.17	1.29	1.34
	10-20	1.37	1.44	1.48
	20-30	1.42	1.47	1.52
Average		**1.32**	**1.40**	**1.44**
Paraplow	0-10	1.14	1.24	1.30
	10-20	1.26	1.38	1.39
	20-30	1.35	1.42	1.43
Average		**1.25**	**1.35**	**1.37**
Chisel + rotary harrow	0-10	1.09	1.22	1.28
	10-20	1.26	1.35	1.41
	20-30	1.36	1.43	1.45
Average		**1.24**	**1.33**	**1.38**
Plough at 20 cm	0-10	1.11	1.21	1.28
	10-20	1.19	1.30	1.35
	20-30	1.37	1.42	1.42
Average		**1.22**	**1.31**	**1.35**
Plough at 30 cm	0-10	1.12	1.21	1.28
	10-20	1.21	1.28	1.34
	20-30	1.26	1.34	1.36
Average		**1.19**	**1.27**	**1.33**

At harvesting, the disk harrow treatment has the biggest value as average on all layers analyzed (1.44 g/cm^3) with a peak 1.52 g/cm^3 at 20-30 depth, corresponding to a high compactation. At the end of the crop rotation the smallest value was recorded at the conventional variant, plough at 30 cm (1.33 g/cm^3) while in the other conventional treatment, plough at 20 cm, or conservation treatments, below 20 cm, values bigger then 1.42 g/cm^3 indicate a tillage-traffic pan. The statistical analysis shows (*table 2*) a significant difference at the disk harrow variant compared with control treatment indicating a high compactation of soil. The negative differences were identified at the both conventional tillage.

Table 2 Bulk density at maize crop (2006-2007) – average values on treatment, depth and growing stages

Treatment	Bulk density (g/cm^3) – average (%)	Comparison with control variant (%)	Differences with control variant (%)	Statistical significations
Disk harrow	1.39	105.30	0.07	**xxx**
Paraplow	1.32	100.46	0.00	ns
Chisel	1.32	100.00	0.00	ns
Average	1.32	100.00	0.00	Control variant
Plough 20 cm	1.29	98.18	-0.03	**oo**
Plough 30 cm	1.26	95.90	-0.06	**ooo**

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

LSD 5%= 0.015% LSD 1%= 0.022% LSD 0.1%=0.033%

Soil penetration resistance at different depths in response to tillage, at the harvesting time and 3–5 days after a rainfall, when the soil water content was nearly at field capacity, is shown in *figure 1*. The penetration resistance of the soil varied with the method of tillage operations. PR in the soil for all the five tillage treatments increased with depth *(fig. 1*). Several researchers have reported that PR is reduced in conventional tillage compared to reduced tillage (Sidiras et al., 2000). The biggest PR in the 0-10 cm layer was found in disk harrow treatment (1.38 MPa) while de minimum value was found in paraplow variant (0.75 MPa). Also the disk harrow variant had a higher PR at 10, 20, 30, 40 and 50 cm depths. 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) with a minimum value of 0.68 MPa on 0-10 layer. Penetration resistance, as average on the layer 0-50 cm was not greater than 2 MPa for paraplow, chisel, and plough at 20 and 30 cm at the soil water content conditions at the time of penetration resistance determination. This value is defined as the upper limit for unrestricted root penetration (Taylor et al., 1966). Exception is the disk harrow variant where was recorded a average of 2.22 Mpa and a peak value of 2.61 MPa, on the 20 -30 cm depth

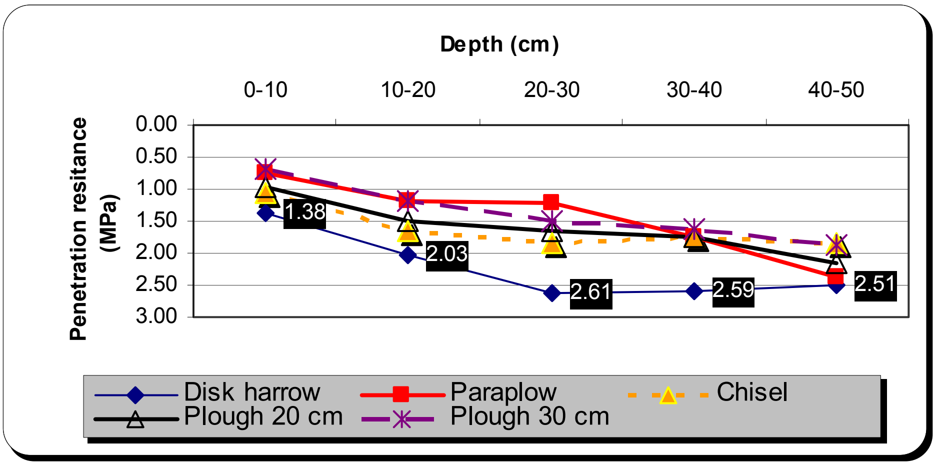

Figure 1 The influence of tillage systems on penetration resistance (averages at harvesting period)

As regarding the aggregate size distribution for the variant plough at 20 and 30 cm dominate the large clods with the diameter between 5-10 mm and >10 mm. Large aggregates or clods, however, have no agronomic value and often create problems for soil management (Dexter and Birkas, 2004).

For the variants chisel + rotary harrow and paraplow the specific classes of aggregates are those with the diameter between 1-5 cm and in a bigger proportion the aggregates < 1mm. In the disk harrow variant has been observed the smallest percent of aggregates > 10mm and the biggest number of aggregates < 1mm width. After the cultivation tillage on vegetation time, in the layer 0-10 cm the situation has been changed compared with emergence time. Hereby, the proportion of the aggregates with the diameter >5 mm decreased and the aggregates ≤ 1mm increased. This phenomenon has the biggest intensity in the disk harrow variant. From the agronomic point of view it is important to create fine aggregates for optimal crop emergence. A good seedbed is obtained, when >50% of the aggregates are <5 mm (Hakansson et al., 2002).

The dynamics of water stable aggregates is shown in *table 3*, but no significant differences statistically ensured is relieved. The water stable aggregates ranged from 75.4% to 79 %. Anyway, it has been observed a 1.1 % positively difference between plough treatment at 30 cm (79%) and control variant and a negative difference of 2.5% between disk harrow variant (75.4%) and the control one (77.9%). Also, Ghuman and Sur (2001), indicate that reduced tillage did not make any appreciable change in the aggregation status of the soil compared with conventional tillage.

Table 3 The influence of tillage system in water stable aggregates (WSA) >0.25mm, averages values on treatment, depth and growing levels

Treatment	WSA – average (%)	Comparison with control variant (%)	Differences with control variant (%)	Statistical significations
Plough 30 cm	79.0	101.41	1.1	ns
Plough 20 cm	78.5	100.77	0.6	ns
Paraplow	78.5	100.77	0.6	ns
Chisel	77.9	100.00	0.0	Control variant
Average	77.9	100.00	0.0	ns
Disk harrow	75.4	96.79	-2.5	ns

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

DL 5%= 7.1% DL 1%= 10.4% DL 0.1%= 15.5%

5. References

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