THE MODIFICATION OF PHYSICAL PROPERTIES OF THE SOIL UNDER THE INFLUENCE OF SOME CONVENTIONAL AND UNCONVENTIONAL TILLAGE SYSTEMS

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Optimal crop rooting soil physical conditions are a result of complex interactions between soil strength and oxygen and water supply to plant roots. Spatial/temporal variability in soil properties can be critical in the evaluation of the effects of tillage management practice on soil and crop parameters. In this paper tillage were evaluated for theirs effects on soil physical and hydrological properties. Tillage treatments were plough to 20 cm, plough to 30 cm, chisel and disc harrow applied to wheat in to been/ wheat/ maize rotation. The experiments have been conducted in the Didactic Station of the University of Agricultural Sciences and Veterinary Medicine – Iasi, Ezăreni Farm, during the period between 2002-2005, on a cambic chernozem with 3,4 % humus and pH 7. Tillage system modify, at least temporarily, some of the physical properties of soil, such as soil bulk density, penetration resistance, soil porosity and soil structural stability. Hydraulic properties of the soil did not differ significantly. All the tillage operation was significantly different in their effects on soil properties.

Keywords*: soil tillage, bulk density, penetration resistance, compactation degree, soil structure, structural stability, qualitative indices of structure.*

Soil tillage, besides new and direct effects, good for plant growing technologies, induces in soil long-term residual effects, which act on its physical and physico-mechanical characteristics, by modifying them (Jitareanu G., & al., 1999, Feiza V. and Cesevicius G., 2006). Soil physical characteristics have a major influence on the way of soil functioning within an ecosystem (Carter M., 1996, Fabrizzi K., & al., 2005). Plant growth and development, water regime and soil solution are tightly connected to soil physical and hydrophysical characteristics (Liebig M. & al., 2004, Pagliai M. & al., 2005). Therefore, the implementation of a certain tillage system must be done in concordance with all the aspects that may be influenced or may influence this system (Horn R., & al., 1994, Liebig M. & al., 2004). This requires the detailed knowledge of all elements contributing to soil fertility increase or diminution (Canarache A., 1990, Fabrizzi K. & al., 2005).

MATERIAL AND METHOD

The experiment was conducted at the Didactic Station of the „Ion Ionescu de la Brad" University of Agricultural Sciences and Veterinary Medicine of Iasi, Ezareni Farm, during farming years 2002-2005, on a cambic chernozem with clayey-loam texture and mean to good fertility, with a moderate humus content and relatively high content in total nitrogen. It also has a mean supply in mobile phosphorus, a good one in potassium, and a weakly acid to neuter reaction. The AxBxC type-experiment was set up according to the method of split-split plot with three replicates, having the area of 25 m2 plot.

We have investigated two variants of the classical soil tillage system – ploughed at depths of 20 cm and 30 cm– and two variants of minimum tillage –Chisel-tilled variant and disk harrow-tilled variant – in the crop rotation made of beans/wheat/maize. For each variant, two different fertilization levels were used (N30 P60 and N60 P60).

This paper presents the results obtained in winter wheat growing as concerns the influence of the tillage method on some soil physical and hydrophysical characteristics. We have taken samples at sowing, emergence and on phenological phases typical of each crop, in order to determine soil moisture, bulk density and total aeration, utile and inactive porosity. We have also calculated wilting coefficient, field capacity, available moisture holding capacity, and settling degree; for the determination of penetration resistance, we have used the dynamic penetrometer.

Determinations were carried out at sowing, on vegetation and at harvesting, at three depths (0-10, 10-20 and 20-30 cm). Statistical processing of data was done by means of the analysis of variance.

RESULTS AND DISCUSSION

a. Influence of tillage systems on soil hydrophysical indices

In winter wheat crop, the mean values of *field capacity,* obtained as average on experiencing years (2002-2005), for each variant, had a diminished variation interval, being comprised between 25.80 % g/g in the upper soil layer at sowing, at the 30 cm ploughed variant, and 22.77 % g/g at the disk harrow-tilled variant, at harvesting.

High values of field capacity (> 25 % g/g, according to ICPA scale, 1987) were registered only at sowing, at all tillage systems, in the surface layer.

We remarked that the values of field capacity diminished during vegetation period and according to depth, indifferently of tillage system; the values were higher as soil mobilization was more intense.

As mean values on profile, we noticed the ploughed variants, which had higher values (23.12 – 23.45 % g/g), and the variants tilled without furrow inverting, which had minimum values (22.89 – 22.94 % g/g).

The statistical analysis of average values /variants, depths or vegetation stages has shown that the positive difference to the control from the 30 cm ploughed variant, although low (1.8 %), was statistically insured (*tab. 1*). At the other extreme, it is the disk harrow-tilled variant, which difference of 1.8% was also statistically insured. Between 20 cm ploughed and Chisel-tilled variants, no major statistically insured differences were signaled.

The potential water stock allowable to plants was slightly influenced by tillage system, the variation interval being diminished both from system to system and in vegetation or at depth.

Studying the mean values of *available moisture holding capacity* in winter wheat crop, we found out that it diminished during vegetation period and at depth, with different intensity, according to base tillage.

Table 1

Influence of soil tillage systems on hydrophysical indices – average values/variant, depth and vegetation stage (2002-2005)

Soil tillage systems	Field capacity		Available moisture holding capacity	
	% g/g	%	% g/g	%
Plough to 30 cm	24.35	101.9*	16.05	102.9*
Plough to 20 cm	23.92	100.1	15.62	100.2
Chisel	23.82	99.7	15.52	99.6
Disc harrow	23.47	98.2^{o}	15.17	97.3^{o}

Control variant – mean values for all variants

$LSD_{5\%}$ = 0.3 (% g/g)	$LSD_{5\%}$ = 0.3 (% g/g)
$LSD_{1\%}$ = 0.5 (% g/g)	$LSD_{1\%}$ = 0.5 (% g/g)
$LSD_{0,1\%}$= 0.8 (% g/g)	$LSD_{0,1\%}$= 0.8 (% g/g)

Soil progressive settling during vegetation period has modified the ratios between pore categories from soil. Great size pores from 0-20 cm layer of the ploughed variant changed into capillary pores, resulting in an increase in the value of potential water stock on profile, at 20 cm ploughed variant (15.70 % g/g) compared to Chisel-tilled variant (15.54 % g/g), although at depth of 20-30 cm, higher values of available moisture holding capacity for Chisel variant (14.84 compared to 14.78 % g/g) were maintained. For this period, the values of the indicator were higher in case of tilled variants with furrow inverting, compared to the ones without furrow inverting.

As the values of the available moisture holding capacity of over 16% , registered especially at sowing, in upper layers, were considered to be “very high” (according to ICPA, 1987), and the ones over 13 % g/g as “high”, it resulted that the tillage system did not worsen this parameter on the soil on which the experiment was conducted.

The statistical interpretation of mean values has shown that 30 cm ploughed variant determined an increase in available moisture holding capacity at depth of 0-30 cm, with a statistically insured difference of almost three percentages, compared to the control.

The variants of 20 cm ploughing and Chisel tillage presented close values between them and compared to the control. Disk harrow tillage alone determined a diminution in *available moisture holding capacity,* the difference of approximate 3% to the control being statistically significant (*table 1*)

b. Influence of tillage systems on indices of soil compaction

The influence of soil tillage on *bulk density* and on layers had a special importance; we could therefore, estimate more accurately how loosening or settling

degree has influenced plant development and yield level. Studying the evolution of mean values of bulk density after three years of experiencing in winter wheat, we found out that at sowing (layer 0-10 cm), they were between 1.10 and 1.17 g/cm^3. The bulk density has increased in layer 10-20 cm, reaching values comprised between 1.23 and 1.28 g/cm^3 in ploughed and disk harrow-tilled variants. In the next depth degree (20-30 cm), the differences between variants were very high, minimum values being registered in the case of variant ploughed at 30 cm (1.24 g/cm^3) and maxima ones in the case of disk harrow-tilled variant (1.41 g/cm^3). The 20 cm ploughed variant had higher values on this depth scale, in comparison with the Chisel-tilled variant (1.38 g/cm^3 respectively, 1.31 g/cm^3).

During the vegetation period, the bulk density has increased in all variants and at all depths. In all variants, the most settled layers were upper layers, and this phenomenon diminished at depth; the lowest differences of values of the indicator between the two consecutive moments of sampling were signaled at the disk harrow-tilled variant. At harvesting, the bulk density on analyzed profile had the lowest mean values at 30 cm ploughed variant (1.39 g/cm^3), followed by 20 cm ploughed variant (1.42 g/cm^3), and Chisel and harrow disk variants (1.44 g/cm^3).

Statistical processing of obtained data, as an average of analyzed profile (0-30 cm) and during the vegetation period , in the three studied years, has shown that bulk density had the highest values, with significant differences, compared to the control (+3.6 %), at the disk harrow-tilled variant. The 20 cm ploughing and Chisel-tilled variants had close values between them and close to the control; the 30 cm ploughing has statistically demonstrated that it diminished settling, indifferently of testing climatic conditions (*tab. 2*).

Table 2

Influence of tillage systems on some indicators of soil compaction condition– mean values per variant, depth and vegetation stage (2002-2005)

Soil tillage systems	Bulk density		Penetration resistance	
	g/cm^3	%	daN/cm^2	%
Disc harrow	1.38	103.4*	25.30	114.7**
Chisel	1.35	100.5	22.70	102.8
Plough to 20 cm	1.34	99.8	21.25	96.3
Plough to 30 cm	1.29	96.4^o	19.02	86.2^{oo}

Control variant – mean values for all variants

LSD $_{5\%}$ = 0.04 (g/cm^3) LSD $_{5\%}$ = 1.5 (daN/cm^2)

LSD $_{1\%}$ = 0.06 (g/cm^3) LSD $_{1\%}$ = 2.2 (daN/cm^2)

LSD $_{0,1\%}$= 0.09 (g/cm^3) LSD $_{0,1\%}$= 3.6 (daN/cm^2)

Studying the average results of *penetration resistance* registered in winter wheat crop, we found out that at sowing, the lowest values were at 0-10 cm layer. At the depth interval of 10-20 cm, because of settling produced by equipments used for seedbed preparation, the values of penetration resistance were high, close to the values shown at the depth of 20-30 cm.

The ploughed variants have generally shown lower mean values on profile (17.08 daN/cm^2 at 20 cm ploughing and 15.38 daN/cm^2 at 30 cm ploughing) than the variants tilled without furrow inverting (18.11 daN/cm^2 in Chisel variant and

19.90 daN/cm^2 in disk harrow variant). By comparing the values of 20 cm ploughed and Chisel-tilled variants at depth of 10-20 cm, we found out that the chisel-tilled variant was more loosened , the values of penetration resistance being of 20.97 daN/cm^2 compared to 21.90 daN/cm^2 at 20 cm ploughed variant.

Because of natural processes from the interval sowing-straw elongation, soil was settled and the values of penetration resistance have increased in all the layers until harvesting; this increase was higher at depth of 20-30 cm.

During the vegetation period, the penetration resistance has increased in all the variants at the depth of 0-30 cm, this increase being higher at the interval sowing-straw elongation and at the depth of 0-20 cm. The lowest values of this index were registered at 30 cm ploughed variant, at all stages and depths, and the highest ones, at disk harrow-tilled variant. In Chisel-tilled and 20 cm ploughed variants, the values were intermediary compared to 30 cm ploughed and disk harrow-tilled variants.

The statistical analysis of mean values has shown that soil tilled only with disk harrow determined a higher soil settling, with 14% statistically insured difference to the control.

The 30 cm ploughing maintained soil more loosened on studied profile, the difference to the control being distinctively significant. The Chisel tillage led to a higher soil settling, compared to 20 cm ploughing, but the differences to the control were not statistically insured (*tab. 2*).

As the absolute values of bulk density or total porosity could not be adequately interpreted, in order to assess the soil settling condition, because their practical significance was different from soil to soil, according to its texture (Canarache A., 1990), a complex indicator was calculated, which included bulk density, total porosity, and texture, respectively, settling degree (Stângă, 1978).

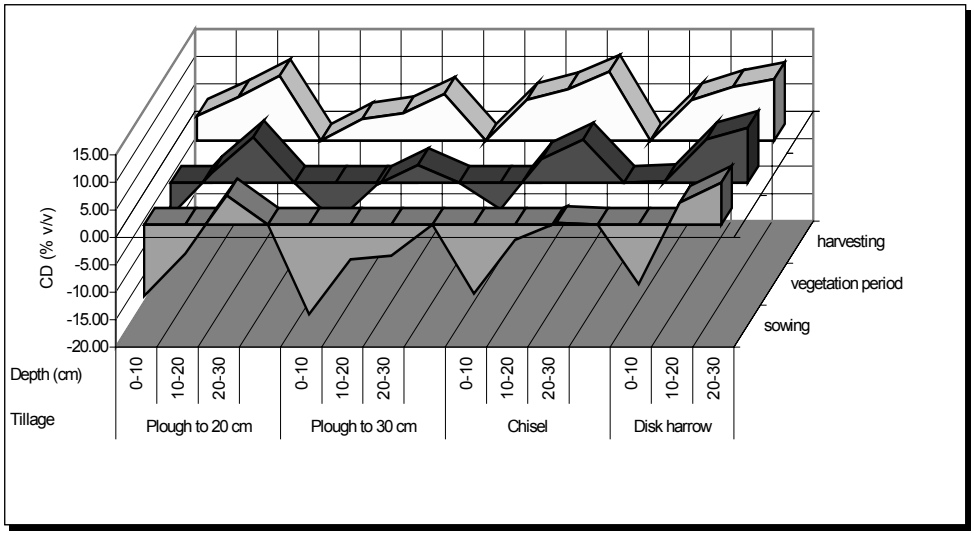

Figure 1. **Influence of tillage system on settling degree in winter wheat crop – mean values**

Studying data obtained in winter wheat crop, we have noticed that the *settling degree* had lower values at sowing and in ploughed layer, for each variant increasing according to depth and once with vegetation development (*fig. 1*).

Until harvesting, the values of settling degree have increased the ploughed variants with furrow inverting being compacted the most intensely at depth of 10-20 cm, where differences were the greatest.

Soil layers, which were not mobilized through base tillage, were compacted with the lowest intensity, because of high initial values of this index.

The values exceeding 10 % v/v, which were found at harvesting in 20 cm ploughing, Chisel and disk harrow-tilled variants, at the depth of 20-30 cm, have shown that soil was moderately settled (according to settling degree I.C.P.A., 1987). The values between 1 and 10 indicated a weakly settled soil, which needed loosening of third emergency (Stângă, 1978).

Our results have shown that in a short-term interval, the settling degree did not change significantly, indifferently of tillage system. A progressive increase in this parameter was registered from sowing to harvesting and according to depth, in the case of all soil tillage variants.

CONCLUSIONS

1. Field capacity diminished during vegetation period and according to depth, indifferently of tillage system. The values were higher as soil mobilization was more intense.

2. The potential moisture capacity available to plants was slightly influenced by soil tillage system, the variation interval of the indicator being diminished both from system to system and on vegetation or depth. Because the values of available moisture holding capacity over 16%, registered at sowing in the upper layers, were very high (ICPA, 1987) and the values over 13 % g/g were high, the tillage system did not worsen this parameter in short term on the soil on which the investigations were carried out.

3. The bulk density has increased in all variants and according to depth; the highest settling degree was found in upper layers, at all variants; the phenomenon was reduced with depth.

4. During vegetation period, as a result of natural processes from the interval sowing-straw elongation, soil was settled; therefore, the values of penetration resistance have increased in all the layers. Until harvesting, the values of penetration resistance have increased in all the layers, this increase being higher at the depth of 20-30 cm.

5. The compactation degree had lower values at sowing and in tilled layer; for each variant, it has increased at depth and once with vegetation development. During the vegetation period, the highest compaction was found in ploughed variants with furrow inverting; the differences between the values of compactation degree at sowing, in vegetation and until harvesting were the highest, especially at depth 10-20 cm.

6. The mean values on the studied profile, between 1 and 10 %v/v, determined at crop harvesting, show that soil was weakly compacted (according to value classes of settling degree I.C.P.A., 1987) and requires loosening of the third emergence; therefore, in a short time interval, the compactation degree is not significantly changed, indifferently of tillage system. A progressive increase in this parameter was registered from sowing to harvesting and according to depth, in all soil tillage variants.

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