THE EFFECT OF DIFFERENT SOIL TILLAGE SYSTEMS ON SOIL STRUCTURE CHARACTERISTICS, IN MAIZE CROP FROM THE MOLDAVIAN PLAIN

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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 structure. 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 2002-2006, on a cambic chernozem with 3,4 % humus and pH 7. Tillage system modify, at least temporarily, some of the structure properties of soil, such structural stability, distribution of aggregates, qualitative indices and mean diameter. All the tillage operation was significantly different in their effects on soil properties.

***Key words**: soil tillage, 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 [6]. Soil physical characteristics have a major influence on the way of soil functioning within an ecosystem [2]. Plant growth and development, water regime and soil solution are tightly connected to soil physical characteristics [8]. According to size, form and forming mode, the soil aggregates may have more or less characteristics favorable to the circulation of water and air, and root penetration [5]. 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 [4, 7]. This requires the detailed knowledge of all elements contributing to soil fertility increase or diminution [1, 3].

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 2002-2006. The experimental site is located in the East part of

Romania (47o07` N latitude, 27o30` E longitude) on a chambic chernozem (SRTS-2003, or haplic chernozems after WRB-SR, 1998), with a clay-loamy texture, 6.8 pH units, 3.7 % humus content and a medium level of fertilization. The soil has high clay content (38-43%) and is difficult to till when soil moisture is close to the wilting point (12.2%). The experimental site has an annual average temperature of 9,40C and precipitation of 587 mm. The experimental design was in a "divided plots design" with three replications. We have investigated two variants of the classical soil tillage system – plough at depths of 20 cm and 30 cm– and two variants of minimum tillage – Chisel variant and disk harrow variant – in the crop rotation made of beans/wheat/maize.

This paper presents the results on the influence of tillage method on the indicators of soil structure characterization. The analysis of distribution and structure hydrostability of structural macroaggregates was carried out according to Tiulin-Ericson method, and certain indicators as mean weighed diameter, quality indices of structure and aggregation index, were determined by calculation.

RESULTS AND DISCUSSIONS

At sowing, the aggregates with higher than 5 and 10 mm diameter were prevalent in variants tilled without furrow inverting. In Chisel-tilled variant, the aggregate categories with ∅ between 1 and 5 mm were prevalent, and aggregates with ∅<1 mm were found at the highest rate. In the layer of 0-10 cm, after conservation works, the ratio between different aggregate categories from the present situation at sowing was changed, the weight of aggregates with ∅=1 mm being increased. On the last stage of studied depth, where the influence of equipments used for conservation works was not signaled, the aggregates >5 mm were prevalent in all variants. Until harvesting, a slight increase in the proportion of structural elements with 3, 5 and 10 mm diameter was found and simultaneously, a diminution in the proportion of small size diameter aggregates, especially in the surface layer. At the last studied depth, there were no great differences compared to previous period, a slight increase in aggregate proportion with higher diameter being noticed.

Table 1

„Mean weighed diameter" to maize crop – mean values on variant, depth and stages of growing, 2002-2005

Tillage systems	Mean weighed diameter		Difference	Significance
	∅ aggregates (mm)	% /C.V.	(mm)	
Chisel	6,30	114,5	0,8	xxx
Plough to 20 cm	5,75	104,3	0,2	
Plough to 30 cm	5,69	103,4	0,2	
Disk harrow	4,28	77,8	-1,2	ooo

Control variant (C.V.)– mean value for all variants

$LSD_{5\%}$ = 0.3 (% v/v)

$LSD_{1\%}$ = 0.5 (% v/v)

$LSD_{0,1\%}$= 0.8 (% v/v)

The mean weighed diameter (MWD) was better emphasized (*tab. 1*). At sowing, the structural elements of great size were prevalent, excepting the disk harrow-tilled variant. The Chisel- tilled variant favored the formation of great diameter structural elements, especially at depths below 10 cm, where there was less influence of equipments used for seedbed preparation. The conservation works have determined the destruction of great size aggregates. In this period, the aggregates lower than 3 mm diameter were prevalent. This phenomenon was felt until the depth of 15-20 cm, but below this depth, the mean diameter of structural elements continued to have great values. Until harvesting, the stress caused by conservation equipments lacking, the aggregation degree was improved, the mean weighed diameter increasing in depth at all the variants.

The statistical analysis of mean values has shown that the Chisel tillage has favored the most the aggregation of soil particles with optimum size and adequate proportion. The *mean weighed diameter* of structural elements had a distinctively significant difference to the average value (control).

Disk harrow tillage, combined with conservation works, resulted in mechanical destruction of aggregates, this assessment being supported by statistically insured differences (*tab. 1*).

The *structure hydrostability* increased once with the depth in all the variants of soil tillage, indifferently of vegetation stage. At sowing, in layer 0-10 cm, the values of the index were the highest for the entire vegetation period.

The highest values were found in ploughed variants, due to structure hydrostability of soil, which was brought from depth. At depth of 10-20 cm, the structure hydrostability had close values, except the case of the disk harrow-tilled variant, where the values were lower than in the other variants. At depth of 20-30 cm, the structure hydrostability was balanced, having close values for all variants.

After carrying out conservation works, minimum values were registered in layers 0-10 and 10-20 cm, and until harvesting, the structure hydrostability has increased, indifferently of tillage system, at all depths, reaching maximum values in layer 20-30 cm, at ploughed variants.

The tilled variants without furrow inverting have determined the highest values of structure hydrostability in upper layers 0-10 and 10-20 cm, and the chisel-tilled variant had, on the average, the best structure hydrostability at depths of 20-30 cm. The disk harrow-tilled variant was separated, in negative sense, from the other variants (*tab. 2*).

Table 2

Structure hydrostability in maize crop – mean values/ variant, depth and vegetation stage, 2002-2006

Tillage systems	Structure hydrostability		Difference	Significance
	∅ aggregates (mm)	% / C.V.	(mm)	
Plough to 20 cm	57,9	105,9	3,2	xx
Plough to 30 cm	56,2	102,7	1,5	
Chisel	54,7	100,1	0,0	
Disk harrow	49,9	91,3	-4,8	ooo

Control variant (C.V.)– mean value for all variants

$LSD_{5\%}$ = 1.8 (% v/v) $LSD_{1\%}$ = 2.7 (% v/v) $LSD_{0,1\%}$= 4.4 (% v/v)

The analysis of mean values on profile and for the entire vegetation period has classified the variants according to data presented in table 4, the differences between variants being greater, and the differences compared to the control, statistically insured. The best structure hydrostability on analyzed profile was determined at the 20 cm ploughed variant, due to higher values of the indicator at depths of 20-30 cm, in comparison with the same depth for the 30 cm ploughed variant. In comparison with the control, the statistically insured negative differences were found only at the disk harrow-tilled variant.

Qualitative indices. These indicators of the structure quality have shown that it varied in vegetation according to soil mobilization degree. We pointed out that in surface layer the structure was damaged during the conservation works (*tab. 3).* Its quality could be considered as bad, because of the high weight of aggregates from categories IV, V and VI, to the disadvantage of those from categories I, II and III. In Chisel-tilled variant the organic matter which remained at soil surface, protected the aggregates from groups I, II and III; this was shown by greater values of I_1 indicator (0.4 compared to 0.2 at all the other variants), indicating a greater participation of >3 mm aggregates and a reduced participation of I_2 indicator (0.3 compared to 0.4 or 0.5) . It showed a reduced participation of 2 mm aggregates compared to the ones with lower diameter. Until harvesting, the structure quality was improved at all variants, being better on profile, in case of ploughed variants.

Table 3

Structure quality indices to maize crop – mean values, 2002-2006

Tillage systems	Depth (cm)	Structure quality indices						The aggregation indices		
		I1			I2					
		Sem.	Veg.	Rec.	Sem.	Veg.	Rec.	Sem.	Veg.	Rec.
Plough to 30 cm	0-10	0,8	0,2	0,5	0,9	0,4	0,4	43,3	39,9	44,5
	10-20	1,2	1,1	0,9	0,6	0,4	0,6	42,2	41,4	44,3
	20-30	0,9	0,8	1,2	0,9	1,3	1,5	41,5	42,6	42,5
	Mean	1,0	0,7	0,9	0,8	0,7	0,8	42,3	41,3	43,8
Plough to 30 cm	0-10	0,8	0,2	0,8	0,8	0,4	0,3	41,5	42,5	46,3
	10-20	1,1	0,9	0,7	0,5	0,5	0,6	42,9	42,6	44,5
	20-30	0,7	0,9	1,1	0,7	0,7	0,8	47,0	42,6	45,0
	Mean	0,9	0,7	0,9	0,7	0,6	0,6	43,8	42,5	45,3
Chisel	0-10	0,7	0,6	0,4	0,8	0,2	0,4	38,1	41,9	43,3
	10-20	1,3	1,0	1,1	0,8	0,8	0,8	37,7	38,4	41,7
	20-30	1,2	0,8	0,9	1,7	2,0	2,1	40,3	40,5	41,6
	Mean	1,1	0,8	0,8	1,1	1,0	1,1	38,7	40,3	42,2
Disk harrow	0-10	0,2	0,1	0,3	0,6	0,3	0,4	41,3	37,7	44,6
	10-20	0,3	0,5	0,4	0,6	0,5	0,4	39,5	39,6	41,1
	20-30	1,6	1,6	1,2	1,8	2,3	3,4	41,7	42,3	44,4
	Mean	0,7	0,7	0,6	1,0	1,0	1,4	40,8	39,9	43,4

The analysis of hydrostable aggregates to total percentage has shown that on studied profile, the structural elements from ploughed variants were more stable at spreading action of water. The values of aggregation index have increased at depth and during vegetation period at all the variants, excepting the disk harrow-tilled variant (below the depth of 10 cm), because of the stress caused by soil continuous settling at this variant, which deteriorate the structure quality with time.

CONCLUSIONS

1. The mean weighed diameter has registered a diminution in vegetation period on layers 0-10 and 10-20 cm, and a slight increase until harvesting. At the depth of 20-30 cm, where the effect of conservation works was not felt, the diameter of aggregates has increased constantly until harvesting.

2. Unlike the other variants, aggregates with great diameter were prevalent in the Chisel-tilled variant, because of accumulation and decay of organic matter at soil surface; this favored the intensification of structure formation. This was found, too, at the depth at which soil was not mobilized through base tillage (20-30 cm), especially in Chisel-tilled and 20 cm ploughed variants.

3. The structure hydrostability, indifferently of the vegetation stage or tillage variant, has increased once with depth, reaching maximum values in the layer 20-30 cm, at ploughed variants. The tilled variants without furrow inverting had high values of structure hydrostability in upper layers (0-10 and 10-20 cm). The Chisel-tilled variant had, on the average, the best structure hydrostability, at depth of 20-30 cm.

4. The qualitative indices of soil structure had a high value during vegetation period until harvesting, indifferently of tillage system. This has shown that during vegetation, a modification of hydrostable aggregate participation and creation of a more favourable ratio between them resulted in increasing structure quality. The analysis of mean values at depth of 0-30 cm in qualitative indices of soil structure has shown that, although structure hydrostability and aggregation index had higher values in ploughed variants (especially at 30 cm ploughing), the structure quality and ratio between structure hydrostability were higher in Chisel-tilled variant, compared to the other variants.

5. The analysis of the percentage of hydrostable aggregates, compared to the total percentage of aggregates, has shown that on studied profile, the structural aggregates formed in ploughed variants with furrow inverting were more stable to the spreading action of water than in the other variants.

6. In case of 20 cm ploughed and below 20 cm disk harrow-tilled variants, where the effect of soil mobilization is no longer felt, the structure quality (according to I1 şi I2) was better than in the case of every year soil mobilization.

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