SOIL STRUCTURE AND THE EFFECT OF MANAGEMENT PRACTICES ON A CAMBIC CHERNOZEM

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The experiment carried out during 2005-2008, was located in the East part of Romania, (47^{o}07` N, 27$^o$30` E), on a cambic chernozem with a clay-loamy texture and 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. The purpose of this study was to evaluate the influence of conventional and minimum tillage systems (disk harrow, paraplow and chisel) on soil aggregate distribution, mean weight diameter (MWD) and water stable aggregates (WSA) in the area of the Moldovian Plateau. As regards the water stable aggregates (WSA) at the harvesting time, we had the biggest average value at the chisel + rotary harrow variant (80.43 %) and the smallest one at disk harrow treatment (76.51 %).

***Key words**: minimum tillage, aggregate stability, mean weight diameter*

Intensive agriculture with heavy machinery can cause soil deformation by compaction and shearing which results in changes in soil structure. For e correct evaluation of the impact of management practices on the soil environment, it is necessary to quantify the modifications to the soil structure. The soil physics properties have a major influence on the soil interaction in ecosystem. The structure is a distinguish characteristic, specific to soils, of a great importance for physics process, chemical and biological, which is developing in soil and in the system soil – plant – atmosphere.

When we have to choice a tillage system we have to think at soil conditions, plant and climatically conditions which can influence or can be influenced by that system [5].

MATERIAL AND METHOD

The experiment was initiated in 2005 and sited at Ezăreni – 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 (for seedbed preparation), and 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 aggregate size distribution, mean weight diameter (MWD) and water stable aggregates (WSA) in the area of the Moldovian Plateau.

Soil samples were taken from the fields just after the sowing of maize, during the vegetation season and right after the harvesting. To determine aggregate size distribution and separation of size ranges of aggregates, the loose soil samples (approximately 5 kg) were brought into the laboratory. 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®. Weights of the aggregates remaining on each sieve were used to determine aggregate size distribution.

The mean weight diameter (MWD) of the water stable aggregates from different soil samples was calculated following the method of *van Bavel (1949):* $MWD = \Sigma(\boldsymbol{X_i} \times \boldsymbol{Y_i})/100$, 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. Four grams of 1–2 mm air-dried aggregates were placed into sieves and wetted with sufficient distilled water to cover soil when the sieve is at the bottom of its stroke. The sieves were allowed to raise and low 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.

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

Measurements of fragment size distribution are most relevant to the germination and early growth of plants in soils that are tilled, structured, and uncompacted by traffic [10]. Distributions of soil fragments (a mixture of primary aggregates resulting from tillage fragmentation) in seedbeds are known to influence emergence and early shoot and root growth of crops.

Soil fragment size distribution has been introduced as a major factor controlling soil porosity and related soil processes in the seedbeds [3,4].

The distribution of soil structural units controls the availability of oxygen, water, and the resistance to penetration by shoots and roots in seedbeds created by tillage.[8, 11, 13]

Braunack M.V. (1995) described an earlier and greater emergence of maize or soybean seedlings when planted in fine (aggregate size between 1 and 2 mm) vs. coarse (aggregate size between 5 and 15 mm) seedbeds.

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. 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 > 10 mm and the biggest number of aggregates < 1mm width. 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 [9].

Table 1

The influence of tillage systems on Mean Weight Diameter (MWD) at winter wheat crop – mean values 2005-2008

Treatment	Depth (cm)	MWD (mm)		
		Sowing	Vegetation	Harvesting
Disk harrow	0-10	3.9	5.1	6.2
	10-20	5.0	5.5	6.4
	20-30	6.3	7.4	7.4
Mean values		5.1	6.0	6.7
Paraplow	0-10	5.8	6.4	6.7
	10-20	6.2	6.3	6.4
	20-30	6.9	7.0	7.1
Mean values		6.3	6.6	6.7
Chisel+ rotary harrow	0-10	4.9	5.7	6.1
	10-20	6.2	6.4	6.7
	20-30	7.2	7.2	7.3
Mean values		6.1	6.4	6.7
Plough 20 cm	0-10	5.1	6.2	6.4
	10-20	5.4	6.3	6.7
	20-30	7.0	7.2	7.4
Mean values		5.8	6.6	6.8
Plough 30 cm	0-10	5.2	6.3	6.6
	10-20	5.5	6.5	6.8
	20-30	5.9	6.5	6.7
Mean values		5.5	6.4	6.7

Knowing the soil structure, as an essential element of soil fertility, has a great importance [6] because it influences not only the physical conditions aeration and food regime but also the accessibility of nutrient for plant, degradation of organically material in soil and microbiological activity [12].

Several management systems can improve soil productivity. By studying aggregate stability it is possible to quantify whether or not the management is ameliorating the natural soil properties and the land capability for agriculture.

For all treatments the MWD of soil aggregates was higher at harvesting than in sowing period. If at the sowing of winter wheat culture were large differences between mean values of 0-30 cm soil profile, these values are close to harvest time *(table 1)*. The lowest value was observed in disk variant (3.9 mm at sowing, on 0-10 cm) while the biggest in disk and plough at 20 cm variant (7.4 mm on 30 cm at harvesting time).

The WSA for all five tillage treatments showed an increasing trend from sowing to harvesting period *(table 2)*. Thus, at the sowing time, we had the biggest average value at the chisel + rotary harrow variant (75.56 %) and the smallest one at disk harrow treatment (70.03 %), a normal value as a matter a fact.

Table 2

The influence of tillage systems on Water-stable aggregates at winter wheat crop – mean values 2005-2008

Treatment	Depth (cm)	WSA (%)		
		Sowing	Vegetation	Harvesting
Disk harrow	0-10	67.79	72.44	74.11
	10-20	68.51	74.00	75.81
	20-30	73.78	77.56	79.59
Mean values		70.03	74.67	76.51
Paraplow	0-10	72.53	76.21	78.17
	10-20	75.47	78.36	79.62
	20-30	76.51	78.84	80.94
Mean values		74.84	77.80	79.58
Chisel+ rotary harrow	0-10	73.01	77.01	78.97
	10-20	76.74	78.96	80.34
	20-30	76.92	79.44	81.97
Mean values		75.56	78.47	80.43
Plough 20 cm	0-10	70.07	74.72	76.58
	10-20	74.31	76.30	77.59
	20-30	75.18	77.46	79.20
Mean values		73.19	76.16	77.79
Plough 30 cm	0-10	70.44	74.59	76.03
	10-20	73.72	75.75	76.93
	20-30	74.00	76.93	78.06
Mean values		72.72	75.76	77.01

On 0-10 cm layer the values are smaller compared with the next two layers 10-20, 20-30 cm, where the values had the tendency easily to increase in all five treatments. The stability of fine aggregates depends on the amount and the stability of organic cementing agents. *Arshad et al. (1999)* point out that aggregates of >0.25 mm were 60% greater in no tillage than in conventional tillage at a depth of 0–5 cm, but showed no difference at a depth of 12.5–20 cm.

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 chisel + 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.

The stability of soil aggregates often decreases for soil under disk harrow treatment compared with the other variants of minimum tillage (chisel and paraplow).

In general, the higher the index value the better the soil's capacity to transmit water and air and to promote root growth and development.

Table 3

Water-stable aggregates at winter wheat crop – mean values 2005-2008

Treatment	WSA (%)	Comparison with control variant (%)	Differences to the control variant (%)	Statistical significations
Chisel + rotary harrow	78.2	103.20	2.5	xxx
Paraplow	77.4	102.25	1.7	xx
Plough 20 cm	75.7	100.00	0	control
Plough 30 cm	75.2	99.34	-0.5	
Disk harrow	73.7	97.36	-2.0	ooo

LSD 5% = 0.9 LSD 1% =1.3 LSD 0.1% = 2.0

The mean values of WSA recorded during 2005-2008, reveal positive statistically significant differences between chisel, paraplow variants and the control treatment (plough at 20 cm), (*table3*). The effects of tillage system on WSA reveal a negative difference at Disc harrow (73.7% WSA) compared with control treatment, difference which is statistically insured at LSD 5%.

CONCLUSIONS

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.

This study on the effect of different tillage practices over a period of 3 year on the clay-loamy soil of Moldovian Plateau – Romania, shows that it resulted in significant changes on MWD, WSA and aggregate size distribution.

The chisel and paraplow variants had the velleity to surpass the 80% limit, being considered as a resistant soil to erosion process with a good aero-hydric regime; the tendency of the macrostructural hydrostability indicator was to grow from seeding to harvesting period.

Chisel and paraplow promoted greater roughness, aggregation, and residue cover compared with intensive tillage, thereby minimizing the risks of wind erosion.

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