LONG TERM EFFECT OF SOIL TILLAGE SYSTEM ON ORGANIC MATTER AND SOIL STRUCTURE CONSERVATION

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Long-term field experiments provide excellent opportunities to quantify the long-term effects of soil tillage systems on the soil properties. The paper presents the influence of conventional plough tillage system on soil structure and humus conservation of soil in comparison with the alternative minimum tillage system (paraplow, chisel plow and rotary harrow). The appliance of minimum tillage systems determine an increasing of the humus content with 0.8-22.1% and an increasing of the hydro stabile aggregates content with 1.3-13.6%, on 0-30 cm depth towards the classical system. In the case of humus content and also the hydro stability structure, the statistic interpretation of the dates shows the increasing of the positive significance of the minimum systems appliance while the soil fertility and the hydro stability of the macro-aggregates were initially low, the effect being the conservation of the soil features and also their reconstruction, with a positive influence upon the permeability of the soil for water.

Keywords*: soil tillage, organic matter, soil structure.*

Humus is an extremely important constituent of soils and is so vital to the many hydrological, biological and chemical reactions required for sustaining plant life. Soil organic matter (SOM) can be a source or sink for atmospheric CO_2 depending on land use, and management of soil, vegetation and water resources (Lal, 2007). Nowadays, internationally is unanimous accepted the fact that global climatic changes are the results of human intervention in the bio-geo-chemical material and water cycle, and the sequestration of carbon in soil is considered an important intervention to limit these changes. Soil structure, soil organic matter conservation and hydrological function of the soil are one of the most important functions determining the fertility, the bioproductive capacity, and soil evolution. The soil through its properties (humus and texture content) and applied technology which modifies the soil structure, porosity, permeability and water capacity (Dick et al., 1994; Moiroizumi and Horino, 2002; Mark and Mahdi, 2004; Feiza et al., 2005; Riley et al., 2005; Jitareanu et al., 2006; Ulrich et al., 2006).

Soil organic matter includes living organisms such as bacteria, fungi, nematodes, protozoa, earthworms, arthropods, and living roots. Organic C (OC) is the C content that is commonly used to characterize the amount of OM in soils

(OM = 1.724 x %OC). Carbon sequestration in soil has net advantageous, improving the productivity and sustainability. The more the organic content in soil is higher the better soil aggregation is. The soil without organic content is compact. This reduces its capacity to infiltrate water, nutrients solubility and productivity, and that way it reduces the soil capacity for carbon sequestration. Also it raises soil vulnerability to erosion through water and wind.

MATERIALS AND METHODS

Our study presents the influence of conventional plough tillage system on soil structure and humus conservation in comparison with the alternative minimum tillage system: paraplow, chisel plow and rotary harrow (which 30% of the crop residue remains on the soil surface). The influence of tillage soil system was studied on several soil types (table 1, WRB-SR, 1998; SRTS, 2003) at the University of Agricultural Sciences and Veterinary Medicine of Cluj-Napoca.

The experimental soil tillage systems were as follows:

Classic system: V_1 – classic plough + disc –2x

Minimum tillage systems: V_2 – paraplow + rotary harrow

V_3 – chisel plow + rotary harrow

V_4 – rotary harrow

The rotation crops were: maize - soybean - wheat and potato. The results of the water stable aggregates and humus content were statistically analysed by ANOVA and Duncan's test (PoliFact, 2002).

Table 1

Soil properties are where the experiments

Tip of soil	Clay content, %	Humus, %	WSA, %	pH	P.m.m., mm	T.m.m, ^{0}C
Chernozem cambic	43.1	3.52	78	6.73	500	8.8
Phaeozem tipic	43.2	3.92	76	6.71	500	8.8
Haplic luvisols	42.0	2.49	65	6.06	613	8.2
Fluvisol molic	41.6	3.01	61	7.25	613	8.2

WSA: Water stability of structural macro-aggregates; P.m.m. - Precipitation medium multi-annual; T.m.m. – Temperature medium multi-annual.

RESULTS AND DISCUSSION

Statistical analysis of the results showed that the differences in humus content depended on the variants of soil tillage and type of soil. Proponents of conservation tillage argue that the soil structure will be maintained by disturbing it as little as possible. Meanwhile, crop residues left on the surface start the biological activity, building up soil organic matter; the resulting healthy soil structure permits water ingress. The end result is a soil that is more productive, is better-protected against wind and water erosion and requires less fossil fuel for land preparation. Our results clearly demonstrate the complex effects of the minimum tillage systems what determine an increasing process of the humus content with 0.8-22.1% (table 2) and an increasing of the hydro stabile aggregates content with 1.3-13.6% (table 3), on 0-30 cm depth towards the conventional system.

The increase of organic matter content and even of humus content is due to the vegetal remnants partially incorporated and to an adequate biological activity in this system. In the case of humus content and also the hydro stability structure, the statistical interpretation of the dates shows an increasing positive significance of the minimum systems appliance while the soil fertility and the hydro stability of the macro-aggregates were initially low, the effect being the conservation of the soil features and also their reconstruction, with a positive influence upon the permeability of the soil for water. More aggregated soils permit more water to reach the root zone. This not only increases productivity, it may also reduce runoff, and thus erodibility potential.

Table 2

The influence of soil tillage system upon humus content (H., %; 0-30 cm)

Tip of soil	Soil tillage systems	Classic plough + disc – 2x	Paraplow + rotary harrow	Chisel plow + rotary harrow	Rotary harrow
Chernozem cambic	Humus, %	3,51 a	3,54 a	3,87 a	3,61 a
	Signification (%)	^{wt}(100)	^{ns}(100,8)	^{ns}(110,2)	^{ns}(102,8)
Phaeozem tipic	Humus, %	3,90 a	4,13 b	3,93 ab	3,98 ab
	Signification (%)	^{wt}(100)	*(106,0)	^{ns}(100,9)	^{ns}(102,2)
Haplic luvisols	Humus, %	2,48 a	2,94 ab	3,02 b	2,82 ab
	Signification (%)	^{wt}(100)	*(118,6)	*(122,1)	^{ns}(113,9)
Fluvisol molic	Humus, %	3,03 a	3,12 ab	3,09 ab	3,23 b
	Signification (%)	^{wt}(100)	^{ns}(103,1)	^{ns}(102,0)	^{ns}(106,5)

Note: wt – witness, ns – not significant, * signification positives, ^{0} signification negatives, a, ab, b - Duncan's classification.

Table 3

The influence of soil tillage system upon water stability of structural macro-aggregates (H.S., %; 0-30 cm)

Tip of soil	Soil tillage systems	Classic plough + disc –2x	Paraplow + rotary harrow	Chisel plow + rotary harrow	Rotary harrow
Chernozem cambic	H.S., %	74,33 a	79,00 b	78,67 ab	80,33 b
	Signification (%)	^{wt}(100)	*(106,3)	^{ns} (105,8)	*(108,1)
Phaeozem tipic	H.S., %	80,00 a	82,33 b	81,00 ab	81,67 ab
	Signification (%)	^{wt}(100)	*(102,9)	^{ns}(101,3)	^{ns}(102,1)
Haplic luvisols	H.S., %	63,67 a	68,33 b	66,67 ab	72,33 c
	Signification (%)	^{wt}(100)	*(107,3)	*(104,7)	**(113,6)
Fluvisol molic	H.S., %	71,33 a	76,00 b	75,33 b	76,33 b
	Signification (%)	^{wt}(100)	*(106,5)	*(105,6)	*(107,0)

CONCLUSIONS

Minimum tillage, with or without straw, results in enhanced soil humus conservation and soil structure stability during crop growth. As a consequence, the root mass, yield components, and yield increased. Soil organic matter management is necessary for a complex of matters including soil, water management, field productivity, biological fuel and climatic change. A high priority must be given to promoting widespread adoption minimum tillage and conservation tillage with the liberal use of crop residue mulch and incorporation of cover crops in the rotation cycle.

The advantages of minimum soil tillage systems for Romanian pedo-climatic conditions can be used to improve methods in low producing soils with reduced structural stability on sloped fields, as well as measures of humus and water and soil conservation on the whole ecosystem.

REFERENCES

1. Dick, W. A., Mccoy, E.L., Edwards, W.M. and Lal, R., 1994. Continuous application of no-tillage to Ohio soils. From Agronomy Journals. 83, 65-73 pp.
2. Feiza, V., Irena Deveikyte, Danute Simanskaite, 2005. Soil physical and agrochemical properties changes, weediness and yield of crops in long-term tillage experiment in Lithuania. Scientific publication, vol. 48, Agronomy, USAMV Iasi.
3. Jitareanu, G., C. Ailincai and D. Bucur, 2006. Influence of Tillage Systems on Soil Phsical and Chemical Caracteristics and Yield in Soybean and Maize Grown in the Moldavian Plain (North – Eastern Romania). In Soil Management for Sustainability, 370-379 pp, IUSS, Catena Verlag, Germany.
4. Lal, R., 2007. Challenges and opportunities in organic matter researches. In Proceedings Organic Matter Dynamics in Agro-Ecosystems, p. 30-33, Poitiers, France.
5. Mark, A. Licht and Mahdi Al-Kaisi, 2004. Strip-tillage effect seedbed soil temperature and other soil physical properties. Soil and Tillage Research, volume 80, Issues 1-2, 233-249 pp.
7. Moroizumi, T. and Horino, H., 2002. The effects of tillage on soil temperature and soil water. Soil Science. 8, volume167, 548-559 pp. Ed Lippincott Williams & Wilkins. Inc. SUA.
8. Riley, H.C.F., Bleken, M.A, Abrahamsen, S., Bergjord, A.K. and Bakken, A.K., 2005. Effects of alternative tillage systems on soil quality and yield of spring cereals on silty clay loam and sandy loam soils in the cool, wet climate of central Norway. Soil and Tillage Research, volume 80, Issues 1-2, 79-93 pp.
9. Ulrich, S., B. Hofmann, S.Tischer and O.Christen, 2006. Influence of Tillage on Soil Quality in a Long Term Trial in Germany. In Soil Management for Sustainability, 110-116 pp, IUSS, Catena Verlag, Germany.
10. PoliFact, 2002. ANOVA and Duncan's test pc program for variant analyses made for completely randomized polifactorial experiences. USAMV Cluj-Napoca.
11. SRTS, 2003. Romanian System of Soil Taxonomy. Ed. Estfalia, Bucharest, 182 pp.
12. WRB-SR, 1998. World Reference Base for Soil Resources. World Soil Resources Report 84. ISSS, ISRIC og FAO, Rome, 88 pp.