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THE EFFECT OF SOME TILLAGE SYSTEMS ON PEDOMORPHOLOGICAL INDICATORS IN DRYNESS CONDITIONS AT MAIZE CROP

M.S. CARA, G. JITĂREANU, F. FILIPOV, IRINA COROI, D. ȚOPA

Universitatea de Ştiințe Agricole şi Medicină Veterinară
***„Ion Ionescu de la Brad" Iaşi**, Aleea M. Sadoveanu nr. 3, Iaşi, 700490, România*
e-mail: caramihai2005@yahoo.com

Abstract: *The main objective of this study consists in the effect of some tillage systems on pedomorphological indicators of cross section made in experimental field Ezareni – Iasi, on the development of advanced agricultural technologies for crop cultivation. In Romania have been conducted many researches on the influence of various tillage systems on physical, chemical and biological indicators and their residual effect, and less insisted on the morphological changes. The study of pedomorphological indicators have been accomplished on cross section (2x0.7m) performed after harvesting maize and the variants were: ploughed at 30 cm depth (V_1), paraplow (V_2), chisel (V_3) and disk harrow (V_4). The novelty and originality of the study consists in illustrating the morphological indicators through images performed from cross section and processed with special programs. The morphological description of cross section of cambic chernozem was based on the pedomorphological indicators presented in development methodology of pedological study (vol. III, I.C.P.A., 1987). Pedomorphological indicators of soil cross section may be additional criteria in choosing a tillage system suited to local climatic features. In conditions of very dry spring, the pedomorphological indicators of cross section where the soil was performed with disk harrow shows on the 9 cm and 21 cm depth a loosening – compactated state aspect confirmed by the values of bulk density between 1.27 and 1.62 g / cm^3. The presence of compact layer on soil surface prevent water infiltration and retention of greater quantities of water in the layer 0 - 9 cm. Effect of drought on plant growth and development was emphasized, whereas much of the water retained in the surface layer of soil is lost through direct evaporation and could not be used by plant.*

Keywords: *pedomorphological indicators, soil physical properties, management systems, soil tillage, maize crop*

INTRODUCTION

Frequently intensive farming practices have the degradation effect of physical chemical and biological properties of soil. Soil tillage is an essential technology link which creates favorable conditions for crops and soil organisms, and reduces weeds and pests attack (MANEA D., 2005). In Romania was generalized the conventional soil tillage system based on annual plowing with topsoil inversion. This generalization lowered the humus reserve, intensified the mineralization of organic matter due to the increase of soil porosity in arable layer, reduced soil structural stability, and increased soil vulnerability to degradation by compaction and erosion, leading to soil degradation in arable and sub arable layer. Research on the influence of various tillage systems on some physical and biological properties of soil and their residual effects have been carried out by CANARACHE A. (1990, 2005), DEMETRIUS M. (1999) JITĂREANU G. (2007, 2008), GUS P. (2008), RUSU T. (2008) etc. Field research of different tillage systems effect on some indicators (morphological type of soil structure, size of structural elements, root distribution, etc.) has been less discussed. Preliminary observations and some experimental data obtained in the Ezareni experimental station showed that practicing conservative tillage systems caused increased heterogeneity of indicators of upper (0-40 cm) soil profile (FILIPOV F., 2007, CARA M., 2008 a, b). Need for advanced agricultural technologies required to initiate research on the influence of various soil tillage systems on physical and morphological indicators of upper soil profile. This paper presents some aspects regarding the change of some pedomorphological and physical soil indicators measured in three tillage systems (plowing at 20 cm, paraplow and disc harrow) to reflect the morphological heterogeneity of soil horizons.

MATERIAL AND METHODS

The case study was conducted in Ezareni Experimental Station Iasi, in autumn of 2007, on a fine textured cambic chernozem. Morphological description of the soil profile was made based on pedomorphological indicators presented in pedological soil studies (vol. III, ICPA, 1987). In order to highlight the effect of different tillage systems on pedomorfological soil indicators we have opened several cross sections perpendicular to the movement direction of agricultural machinery to a depth of 40-50 cm. Notations of horizons under the methodology or soil studies or in recent bibliographic sources (FLOREA, 2003; RADUCU, 2002) and notations designed to reflect the morphological heterogeneity of soil horizons and subhorizons processed by tillage are: **Ap** - bioaccumulative horizon of humus (A) processed by plowing (FLOREA, 2003); **Aph** - the most compacted horizon affected by farming operations (RADUCU, 2002); **Apd** - topsoil tillage with disc harrow for the seedbed preparation; **Apb** - fragments or lumps of soil in the arable layer which are larger than 8-10 cm in diameter; **Atp** - compacted sub arable layer formed due to repeated plowing at the same depth called *ploupan* (FLOREA, 2003).

RESULTS AND DISCUSSIONS

Description and morphological characterization of the soil profile shows that soil type is cambic mezocalcaric regraded chernozem, poorly degraded clayey loam texture, the appearance of calcium carbonate is 78 cm, with an Ap, Atp, Am, AB, Bv1, Bv2 , Bv3k, Cca1, Cca2 and II Ck morphology. Low to moderate soil compaction on 19 to 28 cm deep is shown by polyhedral angular structure and uneven distribution of plant roots that are preferentially located on the structural elements faces. The negative effect of soil compaction is partially offset by dense root network of *Gramineae* plant family and by soil fauna activity. The resulted pores (*cervotocins*) increase soil permeability and promote accelerated water infiltration. Soil developed under the influence of both forest and grassland vegetation. Reduced thickness of the humiferous horizon, about 15 cm smaller compared to the cambic chernozem and the presence of cornevins are showing the polyphasic evolution of these soils. The cambic mezocalcaric chernozem has undifferentiated texture on his profile. After his texture, the soil is in the group of fine textured soils, textural class *clay - loam*, textural subclass *clay - medium loam* (*tab. 1*). Within the soil texture are predominating soil fractions represented by fine clay particle whose diameter is smaller than 2 microns. The range of particle size fractions of loam is between 35.0 and 43.8 %. Distribution of loam in soil profile is uniformly decreasing with depth, giving a maximum of 43.8 % in the arable soil layer and a minimum of 35.0% in Cca2 horizon. The variation of 8.8 % loam content is due to the initial particle composition and to loess deposits presence. The absence of loam films on structural elements faces in the middle of the soil profile (Bv horizon) confirmers the poor initial textural heterogeneity of the parental material. Soil is not as vulnerable to compaction because the coarse sand particle is missing and the dust fractions content is lower than the one of fine sand. Poor physical properties for plant growth due to fine texture are partly compensated by the presence of glomerular structural aggregates.

Upper chernozem cambic part fall within the pH class „weak acid” (Atp horizon) or „neutral” (Am - Bv1). The presence of alkali carbonates in carbonate accumulation horizon (Cca) give „low alkaline” reaction with pH values between 6.68 and 8.19. „Weak alkaline” reaction is recorded in the Bv2 and Bv3 horizons and is due to regradation processes that led to the soaking of the soil middle part profile with calcium carbonate. The regradation process occurs after the aridization of soil climate.

Table 1

Granulometric composition of chernozem cambic mezocalcaric from Ezareni - Iasi

Depth (cm)	Horizon SRTS - 2003)	Size fractions (% g/g)			Texture TT*(T**F**)
		Clay (θ< 0,002mm)	Silt (θ 0,002-0,02 mm)	Fine sand (θ 0,02-2 mm)	
0 - 20	Ap	43.8	30.3	25,9	TT (T, F)
20 - 28	Atp	41.8	31.6	26,6	TT (T, F)
28 - 40	Am	42.6	30.0	27,4	TT (T, F)
40 - 56	Bv_1	41.2	31.9	26,9	TT (T, F)
56 - 80	Bv_2	40.6	31.2	28,2	TT (T, F)
80 - 90	Bv3k	35.9	29.4	34,7	TT (T, F)
90 - 108	Cca1	38.1	31.8	30,1	TT (T, F)
109 - 120	Cca2	35.0	28.5	36,5	TT (T, F)
120 - 150	Cca3	40.2	25.5	34,3	TT (T, F)
150 - 170	Cca4	39.0	27.5	33,5	TT (T, F)

*TT - medium clay loam; T – loamy clay; * - textural subclass;*
*** - textural class; *** - textural class group*

Carbonation of the upper soil horizons by precipitation and deposition of carbonates occurs in dry periods of the year by the capillary rise of soil solution and water evaporation and absorption by plant roots. In the field these processes were highlighted by the presence of carbonate accumulations like effervescences and pseudomicelia in Bv3 horizon. The regradation process is favored by the repeated soil mobilization during the farming operations, which leads to a loss of large water quantities through evaporation and soil wetting front penetration to reduced soil depth.

Figure 1. Morphological appearance of cross section made perpendicular to the direction of soil tillage on ploughed at 30 cm variant, at maize crop

The influence of the tillage system treatment *plowed at 30 cm* on soil pedomorphological indicators

Morphological appearance of the cross soil section in the autumn of 2006 in plowed at 30 cm treatment where seedbed preparation was made with Lemken cultivator is rendered in *figure 1*. Pedomorphological indicators show that the soil is relatively loose both in arable layer and the underlying horizons. Increasing the plowing depth had a favorable effect on soil physical state and the plowpan compacted layer is not very well highlighted in the field. Bulk density values ranged between 1.29 and 1.32 g/cm^3 in the **Ap** horizon, leading to soil classification like „poorly compacted" (ICPA, 1987, vol III). Arable layer underlying horizon (Am) is moderately compacted with bulk density values between 1.37 to 1.45 g/cm^3.

The influence of tillage system treatment *paraplow* on soil pedomorphological indicators

Morphological aspect of soil cross-section tilled with the paraplow at the end of the growing season of maize is shown in *figure 2*. Pedomorphological indicators of soil cross section show that a soil loosening state is present in both the arable layer and the underlying horizons.

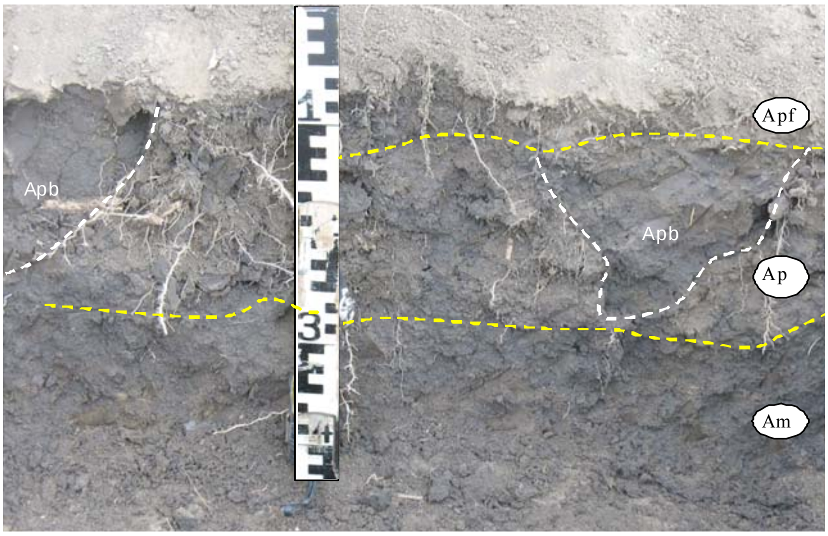
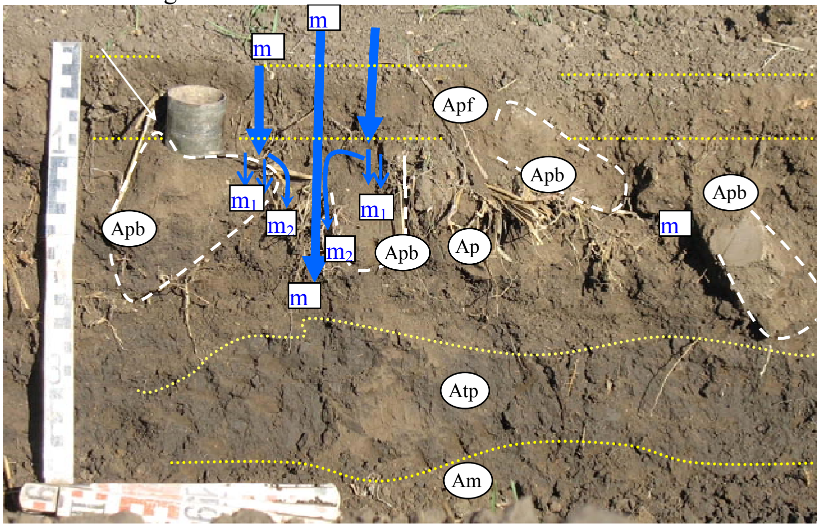


Figure 2. Morphological appearance of cross section made perpendicular to the direction of soil tillage on paraplow variant, at maize crop

An interesting morphological aspect is the presence of more compacted soil fragments marked with *Apb*. These fragments are not penetrated by plant roots due to more intense state of soil compaction. The presence of these fragments promote deeper wetting of the soil found in their immediate vicinity. Plant roots are more common in loosened soil and higher water content could be exploited by the root system. The illustration of water movement and morphological appearance of soil cross-section with compacted fragments is depicted in *figure 3*.

The 0-8 cm soil layer is loose and has an average glomerular structure. Morphological appearance of the soil is not uniform because in some places clods (Apb) with rectangular shape appear as a result of the rotary tiller usage. The presence of these clods of fine porosity results in uneven wetting of the soil surface.

Water from rainfall causes a uniform wetting only in the loosened topsoil. Water infiltration (***m***) in loosened soil layer takes place as influenced by the potential gradient of soil matrix, due to the difference of moisture between the moisted soil by the water that begins to infiltrate and the drier soil below and also by the action of gravitational potential gradient due to thickness of water that infiltrates. Where in the advance direction of the wetting front lies a barrier or an obstacle represented by compacted soil fragments, some water (***m1***) moisten those fragments, following the potential matrix action and the other part (***m2***) moisten the loosened soil in the immediate vicinity and the advance speed of the wetting front and the soil moisted layer thickness will be higher in this case.



LEGEND

⬇	Initial infiltration of water (m) in soil under the effect of gravity and matrix gradient	**m_2**	Water excess that infiltrates in loosened soil as affected by matrix and gravity gradient
↓	Infiltration of water part (m_1) in compacted soil under the effect of matrix gradient	**Apb**	Soil fragments (clods) greater than 8-10 cm in diameter
⤵	Infiltration of water excess (m_2) in terms of soil matrix and gravity gradient	**Ap**	Plowed soil layer
m	Amount of water that infiltrates as influenced by matrix and gravity gradient	**Apf**	Rotovator tilled soil layer
		Atp	Compacted soil layer (plowpan)
m_1	The quantity of water that infiltrates in the compacted as influenced by matrix gradient	**Am**	A molic horizon

Figure 3. Morphological aspect of surface soil before winter wheat sowing plow, disk harrow and vertical rotarry harrow

The influence of tillage system treatment *chisels* on pedomorphological soil indicators

Soil tillage with the chisel resulted in a localized loosening of the soil (Apc) in the advancement direction of the active bodies (*fig. 4*). Another favorable effect of the chisel utilization on the physical soil state consists in localized loosening of the *plowpan* or *hardpan*. Localized soil loosening has favorable effects on soil water movement. The speed of the descending wetting front is higher in loosened parts of the soil, favoring higher accumulation of water reserves (especially during cold season) and also reducing water losses by evaporation. Switching between the arable horizon and the compacted soil layer from below is clear and straight.

The soil tillage with chisel plow and the seedbed preparation with vertical or horizontal rotary tiller, especially in dry years is a possibility of adjusting the tillage system on local climatic conditions and also a mean to improve the physical status of upper soil layer soil by the interruption of compacted layer known as *hardpan* or *plowpan*.

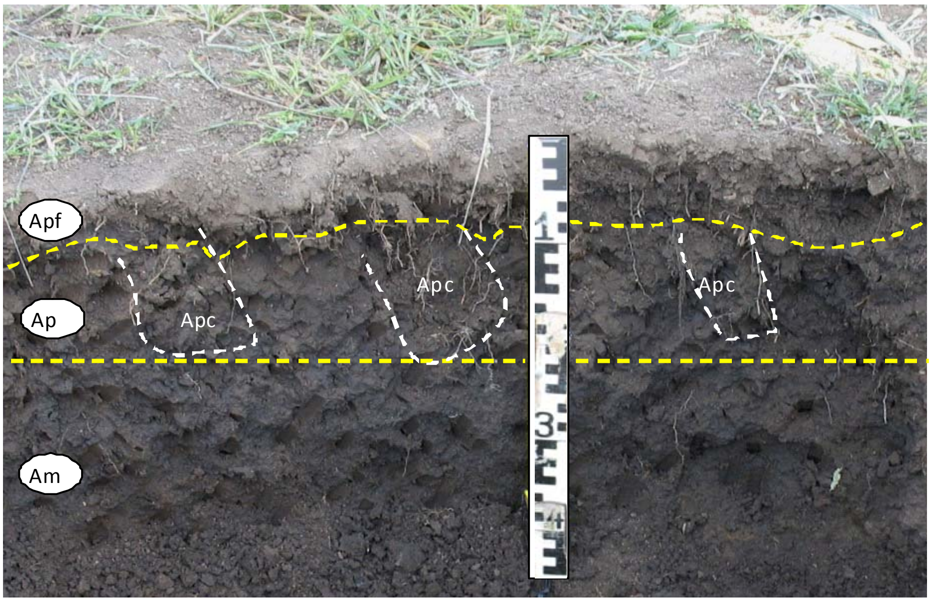


Figure 4. Morphological appearance of cross section made perpendicular to the direction of soil tillage on chisel variant, at maize crop

The influence of tillage system treatment *disk harrow* on pedomorphological soil indicators

Pedomorphological indicators values of surface soil layer (0 - 9 cm) tilled with the disc harrow are showing a relatively homogeneous state of loosening. Bulk density values of 1.16 to 1.22 g/cm^3, confirms the relative homogeneity of topsoil loosening in this treatment. Noteworthy is that loosened soil was maintained during period between the sowing and until after corn harvesting. We believe that the maintenance of the loosened soil surface layer is due to the tillage operations executed before sowing the corn and to a lower intensity self-mulching effect because of the moistening-drying repeated alternance of the soil with fine texture (loam = 41.2 to 43.8%), which took place in the second part of the growing season. If in the first part of the growing season, maize lasted more to drought installed in the spring of 2007, from inflorescence emergence to early maturity when the soil moisture should be 60 - 80 % from field capacity, plants became sensitive and water shortages led to irreversible wilting processes. Although in August and September the accumulated rainfall increased by 96.8 mm compared to the multiannual mean value (98.4 mm), wilted corn plants have not fully resumed their growth which led to significant lower yields. Pedomorphological indicators of soil layer located between 9 and 21 cm depth indicates an uneven compaction - loosening state confirmed by the bulk density values between 1.27 and 1.62 g/cm^3. Soil is presenting a more pronounced state of compaction in microsurfaces with a higher weediness. Pedomorphological indicators of soil layer located between 9 and 21 cm depth indicates an uneven compaction - loosening state confirmed by the bulk density values between 1.27 and 1.62 g/cm^3. Soil is presenting a more pronounced state of compaction in microsurfaces with a higher weediness. The lowest bulk density values (1.27 and 1.31 g/cm^3) were locally highlighted in soil areas crossed by local fasciculate very common roots of weed species *Echinochloa crus - galli*. Most of the ***Ap*** horizon (*fig. 5*) appears to be moderately - strong compacted with bulk density values over 1.62 g/cm^3.

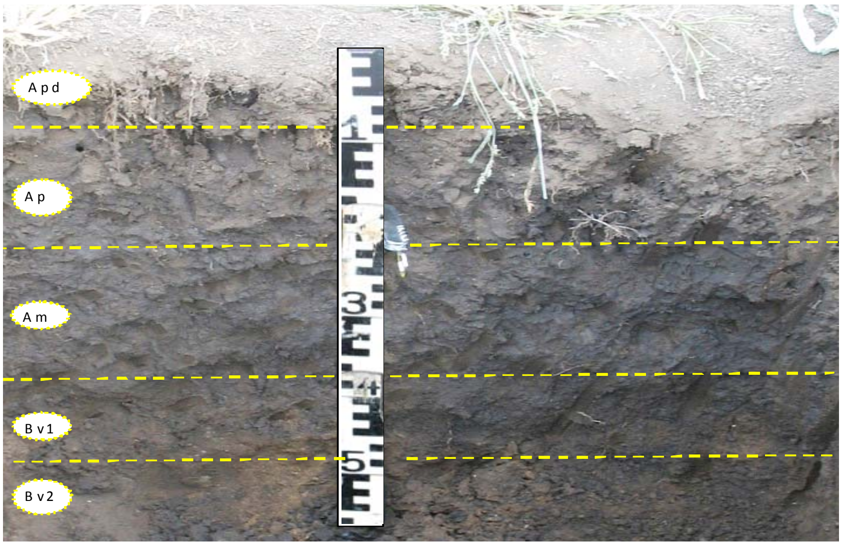


Figure 5. Morphological appearance of cross section made perpendicular to the direction of soil tillage on disk harrow variant, at maize crop

The presence of a compact layer at shallow depth limited water infiltration and produced the retention of greater water quantities in 0 - 9 cm depth. The drought effect on plant growth was less emphasized, whereas much of the water retained in the surface layer of soil is lost through direct evaporation and could not be used by plants. Rainfall recorded in August and September resulted in a relatively uniform wetting of the loosened soil and uneven wetting in the soil layer with formed cracks which favored local infiltration of water and an uneven moisten from the outside inwards of these cracks. In the *A mollic* horizon between 21 and 30 cm soil is *moderately - high compacted* with the bulk density values between 1.54 and 1.66 g/cm^3.

CONCLUSIONS

1. Between fragments with massive structure (***Apb***) existing in both ***Ap1*** horizon and the plowed layer to a depth of 20 cm (***Ap2***) soil loosening state is present, a fact confirmed by the relatively uniform distribution of fasciculated wheat roots.

2. Bulk density values of massive soil fragments (clods) between 1.47 and 1.63 g/cm^3 is framing the soil within the class of „moderate” and „strong” loosening-compaction state.

3. Bulk density varied in depth during the growing season depending on the tillage system treatment; in the depth of 10-20 cm is observing a layer with values ranging from 1.28 to 1.45 g/cm^3, due to compaction produced by agricultural machinery used in crop growth period.

4. Pedomorphological parameters are framing the soil in Cernisol Class, cambic type, mezocalcaric subtype and variety and the occurrence depth of calcium carbonate is 68 cm.

5. Soil tillage and seedbed preparation with vertical or horizontal rotary tiller, especially in dry years is a possibility of adjusting the tillage system on local climatic

conditions and also a mean to improve the physical condition of the soil upper soil part by interruption of hardpan or plowpan.

6. Pedomorfological sectional parameters of paraplow tilled soil at the end of maize growing season indicate that loosened soil layer is present in both plowed and the underlying horizons.

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