THE EFFECT OF SOME TILLAGE SYSTEMS ON SOIL PEDOMORPHOLOGICAL INDICATORS IN DRYNESS CONDITIONS ON SOYBEAN CROP

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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 [16]. Pedomorphological indicators of soil cross section may be additional criteria in choosing a tillage system suited to local climatic features. The cross soil section perpendicular to the direction of tillage in the chisel + superficial rotary tiller plot has a *mildly loosened* aspect, and locally on the tractor wheel tracks the soil is *highly compacted.* The repeated disc harrow use determined soil structure degradation by fragmentation of the elements and the reduction of their mean diameter. On tractor wheel tracks the soil structure is massive and the compaction process can be observed to a depth of 20 cm. In the underlying horizon (***Ap***) the soil maintains mildly to moderately compacted. Locally the soil is crossed by vertical or slightly oblique galleries resulted from soil macrofauna activity. In the subarable horizon formed a dense and compacted soil layer known as *plowpan* or *hardpan.*

Key words: pedomorphological indicators, soil physical properties, management systems, soil tillage, soybean crop.

MATERIAL AND METHOD

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). This papers's novelty and originality consists in the illustration of pedomorphological indicators with images taken from cross soil sections and processed further with special software programs.

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* (*table 1*).

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 (ϕ< 0,002mm)	Silt (ϕ 0,002-0,02 mm)	Fine sand (ϕ 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*

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. 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.

The soil adsorbtion complex is mostly saturated with calcium exchangeable ions (87.69% and 91.0% from soil adsorbtion complex) followed by magnesium, potassium and sodium. Exchangeable magnesium values are ranging between 1.41 to 1.65 me/100 g air-dried soil. The lower values of this indicator are in the first half of soil profile, in A and Bv horizons. Sodium content is 4.7% - 6.88% on 80 - 170 cm depth, indicating a light sodization of those soil horizons (ac). The exchangeable potassium values vary by 0.22 me/100 g air-dried soil, the highest values being in 0-40 cm topsoil layer (*table 2*).

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.

Table 2

Exchangeable cations, pH values, and $CaCO_3$ on cambic mezocalcaric chernozem's profile from Ezăreni – Iaşi county

Depth (cm)	Horizons SRTS - (2003)	$CaCO_3$ (%)	pH	Reaction class	Exch. K (me)	Exch. Na. (me)	Exch. Ca (me)	Exch. Mg (me)	CEC (me)
0 - 20	Ap	0.0	6.68	ldly acidic	0.44	0.17	15.21	1.65	21.22
20 - 28	Atp	0.0	6.78	ldly acidic	0.34	0.23	15.38	1.59	20.36
28 - 40	Am	0.0	7.01	eutral	0.32	0.26	14.54	1.41	18.43
40 - 56	Bv_1	0.0	7.12	eutral	0.26	0.15	11.85	1.07	15.42
56 - 80	Bv_2	0.0	7.32	ldly alkaline	0.28	0.17	19.05		19.50
80 - 90	Bv3k	3.2	7.95	ldly alkaline	0.30	0.87	17.35		18.53
90 - 108	Cca1	17.3	8.08	ldly alkaline	0.32	1.05	15.20		16.58
109 - 120	Cca2	10.8	8.14	ldly alkaline	0.29	1.02	15.27		16.58
120 - 150	Cca3	13.4	8.16	ldly alkaline	0.44	0.96	15.18		16.58
150 - 170	Cca4	16.5	8.19	ldly alkaline	0.29	0.94	12.43		13.65

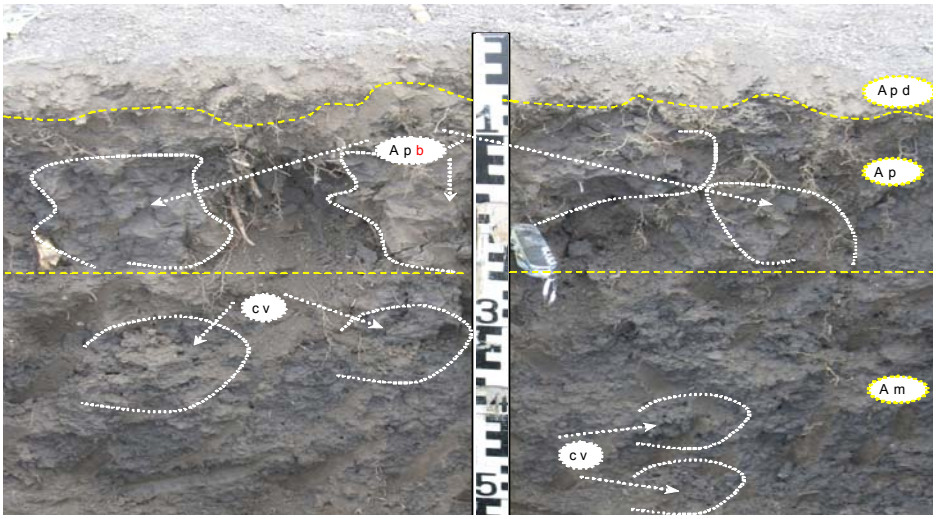

Figure 1 **Morphological appearance of cross section made perpendicular to the direction of soil tillage on ploughed at 30 cm variant, at soybean crop**

The influence of *paraplow* tillage system on some soil pedomorphological indicators. The aspect of soil cross section in the paraplow tilled plot is shown in *figure 2*. The pedomorphological indicators of the cross section are showing that the soil is loosened in the rotary tiller superficial zone of impact. The loosening state of soil between 5 (9) and 24 cm is heterogenous. The soil material between the *moderate - high compacted* fragments of 15 – 20 cm in diameter is *mildly loosened*, wich is also confirmed by the relatively homogenous distribution of plant roots. The high frequence of *cervotocins* (lumbricidae galleries) in Am horizon shows an intense biological activity in the soil. The galleries are partially compensating the poor soil physical properties (air-filled porosity). The bulk density values of massive strucured soil fragments of 1.48 – 1.68 g/cm^3 are classifying the soil in the loosening-compaction scale as *medium* and *high compacted*. The horizon beneath arable layer is *mildly loosened* with mean bulk density value of 1.26 g/cm^3.

The influence of *chisel* tillage system on some soil pedomorphological indicators. The aspect of soil cross section in the *chisel* tilled plot where the soil was superficially mobilised with the horizontal rotary tiller is *mildly loosened* and locally on the tractor wheel tracks the soil is *highly compacted.* The chisel tillage determined a local loosening state of the soil (***Apc***) in the advancement direction of the active chisel bodies

(*fig. 3*). The local loosening state favorized a more profound water infiltration within the soil profile. The downward submission of the wetting front has a higher speed in the loosened parts of the soil favoring higher accumulation of water reserves (especially in winter) and also reducing water loss by evaporation.

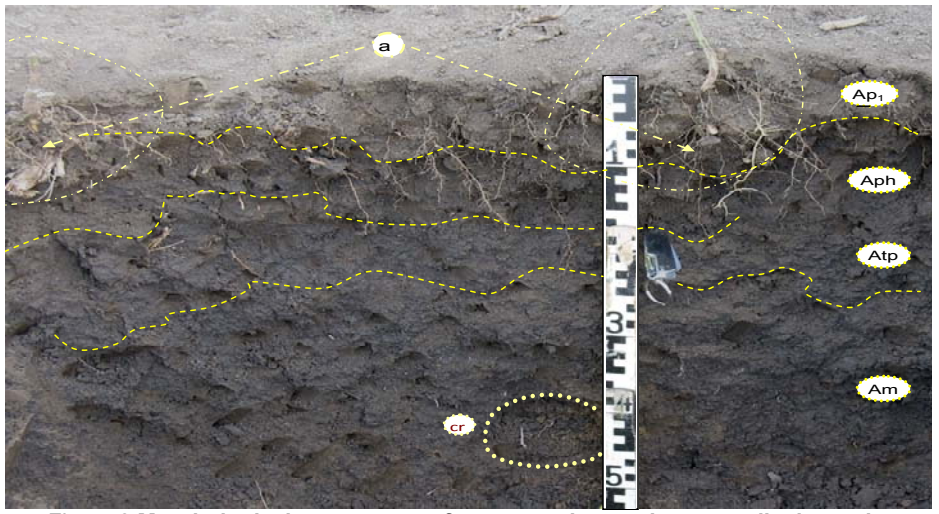

Figure 2 **Morphological appearance of cross section made perpendicular to the direction of soil tillage on paraplow variant, at soybean crop**

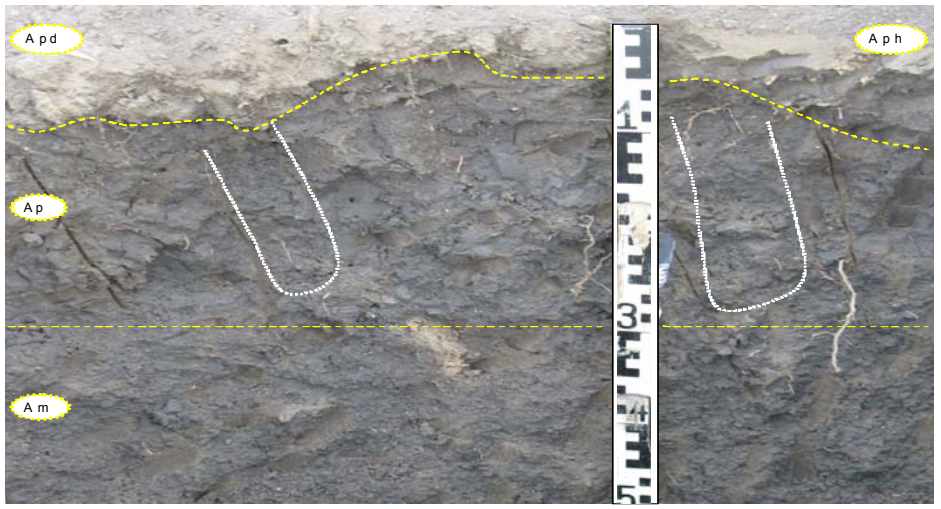

Figure 3 **Morphological appearance of cross section made perpendicular to the direction of soil tillage on chisel variant, at soybean crop**

The influence of *disc harrow* tillage system on some soil pedomorphological indicators. The loosening state of the soil surface layer tilled with the disc harrow is heterogenous (*fig. 4*). Making repeated tillage with disc harrow caused a degradation of soil structure by fragmenting the structural elements and reducing their size (**A**). On tractor wheel tracks the soil structure is massive and compaction process manifests to a depth of about 20 cm (***Aph***). In the underlying horizon (***Ap***) the soil remains *low* to *moderate compacted*. Locally, the soil is crossed by vertical or slightly oblique galleries resulted from the activity of soil macrofauna. Below the arable horizon a dense and compacted layer known as plowpan or hardpan is formed. This layer is crossed by local earthworms galleries. These organisms, were called by Darwin *biological plows* because their soil loosening activity.

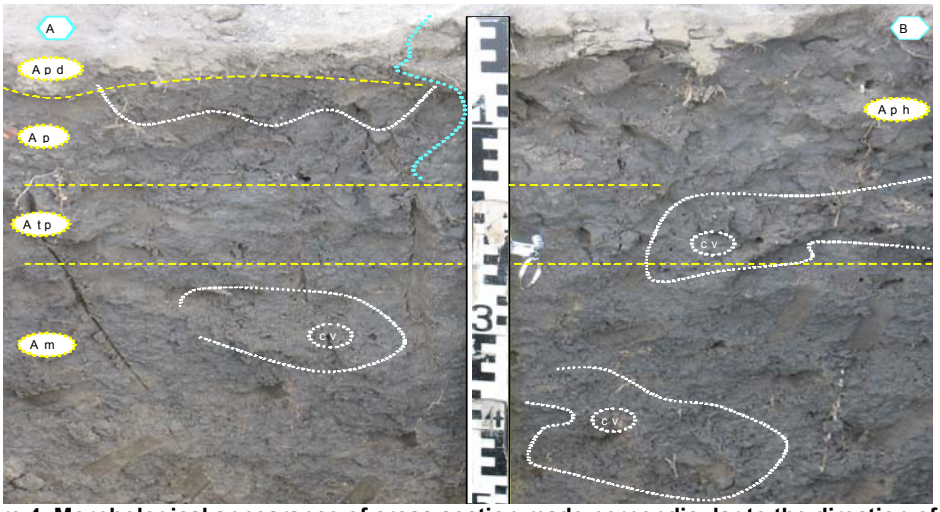

Figure 4. Morphological appearance of cross section made perpendicular to the direction of soil tillage on disk harrow variant, at soybean crop

CONCLUSIONS

The cambic chernozem's superior part has a *„mildly acidic"* pH (Atp horizon) or *„neutral*" pH (Am - Bv1). The presence of carbonates in the carbonates accumulation horizon (Cca) determines a *„mildly alkaline"* soil reaction with pH values ranging between 7.68 and 8.19. A *„mildly alkaline"* soil reaction exists in Bv2 and Bv3 horizons also due to regradation processes wich led to soil imbibition with calcium carbonate in the middle part of the profile.

The pedomorphological indicators of cross section perpendicular to the direction of soil tillage on the plots ploughed at 30 cm in the autumn of 2006 are revealing a relatively loosened soil layer wich includes the arable and subarable horizons.

The tillage using chisel and the seedbed preparation with vertical or horizontal rotary tiller, especially in dry years, is an opportunity to adjust tillage system to local climatic conditions and also a mean to improve the physical condition of the soil upper part by breaking the continuity of the layer known as *hardpan* or *plowpan*.

Morphological appearance of cross section perpendicular to the direction of soil tillage on chisel variant where the soil was superficially mobilised with the horizontal rotary tiller is *mildly loosened*, and locally on the tractor wheel tracks the soil is *highly compacted.*

Between the soil fragments with massive structure (Apb) identified both in Ap1 horizon and in the arable layer tilled at 20 cm depth (Ap2) the soil is loosened, confirmed by the relatively uniform distribution of soybean crop roots.

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