ELEMENTS OF EVOLUTION OF TYPOGENETIC ELEMENTARY PROCESSES IN CHERNOZEMS FROM ORCHARDS

Gheorghe JIGĂU

e-mail: gheorghe.jigau@gmail.com

Abstract

Surfaces used under orchards represent agricultural landscapes that engage cycle of substances and specific energy. This is materialized in different regimes and pedogenesis processes in the arable and forest lands. Among the features mentioned first of all hold the high degree of heterogeneity in space and hydrothermal and airhydric regimes. Therefore significant changes are suffering typogenetic processes: formation and accumulation of humus, carbonates migration and structure. At the same time in the soil is installed a stable trend of soil solution alcanization and transformational capacity reduction.

Key words: agricultural landscape, hydrothermal regimes, airhydric, elementary pedogenetic processes, humification processes, carbonates migration, structural-aggregate composition, transformational capacity

Orchards intensification implies the cultivation necessity of several fruit trees generations on the same land. At the same time it is known extended practice of woody monoculture leads to soil tiredness. Therefore identification of ways to avoid or mitigate this phenomenon becomes current. Success of this can be ensured only under detailed studies on the processes that are performed over time in the soils of plantation from the time of trees planting. These hold several specific features and frequently extended to the exchange of substances and energy, but its intensity depends on the initial state of soil, degree of soil pretability in the establishment of orchards depending on their composition and maintenance charging. Following researches in this area more frequently these were related to land pretability for establishment of orchards, tillage systems, fertilization, plantations rotation, irrigation and evolution of physical features. Despite these researches practically until 1996 have not been recorded investigations in this field which arise soil processes in plantations.

MATERIAL AND METHOD

Investigation were conducted under production conditions located in North (Varatic and Pepeni villages from Rascani and Sangerei rayons) and central part of Moldova (Stauceni and Cojusna villages) in the framework of arranged stationary lands. These studies included applied activities in the field and laboratory analysis. Applied activities in the field supposed morphometric measurements in the trenches framework placed under row spaces (tree) – space between rows (tree). Trenches length constitutes 5-6 m and their depth 1.0-1.2 m. During these were studied: thickness dynamics in space (arable, subarable, A+B and B), effervescence depth and carbonates depth visibility. In addition was measured bulk density by using Kacinski compactimeter and soil moisture at the sampling time. Determination of bulk density supposed five replications in humus horizons (Ap-Aph-A-Bdes, BI) and three repetitions in underlying horizons. Laboratory analyses were preformed through standard methods: determinations of particle size composition through pipetting method, soil were prepared with sodium pyrophosphate; determination of humus – TINAO method; determination of total nitrogen – Tiurin method; determination of carbonates – gas volumetric method; determination of pH – potentiometric method; determination of bivalent cations retained – complexometric method; structural analysis – aggregate – Savinov method; Porosity was calculated by using relation Et= (I – Pb/Ps) 100 where Pb bulk density, 40 % and Ps is solid phase density.

RESULTS AND DISCUSSIONS

Recent studies have established that multiannual plantations in general and in particular orchards are agricultural landscapes with natural-technogenic specific substances cycles. According to the observation within orchards as well in forested lands during winters are accumulated higher amounts of snow than in open spaces (Agroclimatic guide in the Moldavian SSR., 1969). The same reference states that snow depth in orchards depends on the density and age of plantations. With higher density and ages the amount of water accumulated in them is high (tab.1).

Table 1

Snow depth in the various ways of land use (State Hydrometeorological data) in Stauceni, Chisinau (January month)

Utilization	Years					
	1995	1996	2001	2003	2008	2013
Arable land	10.3	17.5	7.5	8.0	15.6	17.8
Orchard, 16 year	14.7	13.9	12.8	13.3	22.3	15.3
Orchard, 24 year	15.4	14.8	13.7	14.9	23.9	28.5
Orchard,37 year	18.0	15.3	14.1	13.7	24.5	28.8
Forested strip	15.0	14.4	15.8	16.3	22.0	25.1

Similar data were established by V. A. Potapov (1982) in the central chernozem zone. From the reference it has been reported that in spring total amount of formed water during snow melting (up to 2000m^3/hectares) is stored about 42-48 % in the soil under orchards, while under soil of arable land is stored only 23-35 %. At the same conditions P. G. Kopytko (1986) noted that under orchards as well in forested spaces snowy reserves are with 50-100 % higher than in open arable spaces. According to cited author calculations during spring water reserves in the layer 0-500 cm under orchards conditions are with 117 mm higher than in arable land which exceed with 45.4 mm in the 3 m layer and with 45.2 in the 4 m layer. In the layers 2 m and 4 m these are higher, up to 10.3 and 11.8 mm. The first layer of water reserves within orchards is larger with 4.3 mm than same layer from arable land. A significant role in the water reserves accumulation into orchards soils have temporary heating periods recorded frequently in January and February. In this regard we noted that in some years during such period snow is melting and all water is accumulated. Water storage into orchards soils is favored by the fact that soils are weakest frozen at less depth. Such cases were noted in 1966, 1971, 1975, 1981 and 1986 and more recently in 2001 and 2013. However, in plantations melting snow follows slower. According to the observations snowmelt period revealed an average with 3-5 days in orchards longer than in open arable land. In the northern zone compared to the center orchards snow sometimes is taken 2-3 weeks later. As a result described characteristics confirm higher water reserves in spring (tab 2, 3).

Table 2

Water reserves dynamics in multiannual plantations and arable land Stauceni, Chisinau (mm)

Layer	Orchards, 16 year			Arable land		
	Spring (1)	Autumn (2)	1-2	Spring (1)	Autumn (2)	1-2
2008						
0-100	232	98	134	208	67	139
100-200	186	84	102	161	78	83
200-300	163	71	92	160	83	77
0-300	581	254	328	529	228	299
2013						
0-100	291	195	96	236	147	89
100-200	213	108	105	204	133	69
200-300	198	105	93	190	105	85
0-300	702	408	294	630	385	253

Table 3

Water reserves dynamics in multiannual plantations and arable land Stauceni, Chisinau (mm)

Layer	Orchards, 37 year			Arable land		
	Spring (1)	Autumn (2)	1-2	Spring (1)	Autumn (2)	1-2
2008						
0-100	262	93	168	208	67	139
100-200	266	101	165	161	78	83
200-300	258	117	141	160	83	77
0-300	786	311	475	529	228	299
2013						
0-100	298	98	200	236	147	89
100-200	283	118	165	204	133	69
200-300	268	131	137	190	105	85
0-300	849	347	502	630	385	253

The first investigations in this area regarding soils evolution in orchards referred to the evolution of processes during formation and humus accumulation. In this respect we tend to mention that it appears some features that imply some particularities. In case when soil from orchards is maintained under black field regime the decomposition-transformational processes and organic matter humification is concentrated on the surface and carried many common features with its analog forested conditions. In case when soil in the planting of trees is maintained under a black field transformation process of decomposition and humification of organic matter is concentrated on the surface and carries many common features with its analog forest conditions, while is detachable to steppe ecosystems. The amount of organic debris framed in pedogenesis in general and humification in particular are lower than under steppe ecosystems. Therefore quantities of humus produced annually are 1.6 to 2 times lower than in steppe ecosystems and agrophytocenosis. Humification process holds multiple characteristic features under orchards. In this respect we mention two particularities:

a) Vegetal debris is deposited predominantly on surface. Its decomposition and transformation is influenced by climatic agent dynamics (temperature and humidity). In such conditions humification processes is accompanied by organic substances formation with polymerization and condensation high degree. Following the newly humic substances formed it possesses a higher degree of mobility and percolation from formation place through vertically descending water flows on soil profile. Radicular debris is stored in the middle segment of profile (below 40-50 cm). Decomposition in this area of profile resulted in condition of less dynamic airhydric and hydrothermal regimes in time.

Resulted humic substances during humification processes partially are accumulated. Mobile compound in the cold season are leached by water descending flows. As a result in old multiannual plantations humus layer has a thickness greater than arable land. It thickness has a minimum 3-4 cm and maximum 8-11 cm. Morphometric measurement described in the field and laboratory analysis indicated enhancement of humus layer thickness in soils from orchlands in horizons Am, B and BI. Production particularities, displacement and humus accumulation in plantations is materialized in humus soil profile. Subsoiling works carried out at the time when plantation has established lead to humus profile inversion. Further processes described above lead to more intensive humus accumulation in the top 0-40 cm due to decomposition of vegetal debris and in the layer 50-90 cm from the decomposition of organic radicular debris. Therefore structure of soil humus profile under orchards significantly attenuates the difference of humus content in the surface horizon (Am) and underlying horizons (tab. 4).

Table 4

Humus content in the soils under orchards and associated arable land (%)

Depth. cm	Typical chernozem humus moderated			Typical chernozem humus lower			Typical chernozem humus moderated			Typical chernozem humus moderated		
	Stauceni			Cojusna			Varatic r. Raşcani			Pepeni r. Sangerei		
	Orch. 9 year	Orch. 23 year	Arable land	Orch. 19 year	Orch. 31 year	Arable land	Orch. 29 year	Orch. 43 year	Arable land	Orch. 33 year	Orch. 47 year	Arable land
0-20	2.05	2.82	3.83	2.53	3.01	3.04	3.77	3.31	3.87	3.51	3.18	3.08
20-40	1.89	2.65	3.46	2.84	3.34	2.56	4.12	4.08	3.29	3.74	3.85	3.44
40-60	1.78	2.47	2.17	2.29	2.70	1.76	3.54	3.76	2.54	2.98	3.07	2.58
60-80	1.27	2.13	1.33	2.21	2.43	1.68	2.96	2.99	1.71	2.23	2.64	1.95
80-100	0.93	1.69	0.97	1.56	1.35	1.39	2.42	2.49	1.09	1.70	1.89	1.40
100-120	0.42	1.06	0.20	0.98	1.12	0.97	1.34	1.37	0.57	1.11	1.16	0.91
Mean content 0-120 cm	1.39	2.14	1.99	2.07	2.33	1.90	3.03	3.00	2.20	2.55	2.63	2.22

The forested land and arable land are distinguished by substantial variability of humus content in soils (tab. 5, 6). Maximum humus content is recorded on the rows. Processes of formation and humus accumulation favored greater amount of organic debris and grass debris inclusive. Also are created more favorable hydrothermal and airhydric regimes these are more stable over time. Minimal is the content of humus in strongly compacted areas formed after crossing agricultural machinery. Our research showed that among them up to 60-70 cm depth intrinsic parameters does not provide conditions for processes of formation development and humus accumulation. Spaces between technical traces are characterized by smallest quantity of debris. In addition, space between technical traces limited formation of humus in autumn and spring even though excessive loosening favors mineralization of organic substances. Summer these are limited by excessive heating of upper soil segment nevertheless during dry years is represented by moisture deficit. As a consequence in the spaces between technical traces humus mineralization processes predominate. Therefore on a background that offers an apparent acceptable situation orchards soils contain necessary reserves of humus to deal with technoanthropogenic pressure exerted on soil and to assure landscape normal functionality.

Table 5

Spatial variability of humus content under orchards soil (North Zone)

Soil Localities	Depth. cm	Humus content. %		
		Row	Technique traces	Spaces between technical traces
1	*2*	*3*	*4*	*5*
Typical chernozem humus moderated (Varatic)	0-10	4.38	2.97	3.12
	10-20	3.91	2.83	2.75
	20-30	3.54	2.60	2.68
	30-40	3.11	2.55	2.57
	40-50	2.65	2.41	2.48
	50-60	2.11	2.09	2.13
	60-70	1.73	1.88	1.70
	70-80	1.36	1.19	1.24
Typical chernozem humus moderated (Pepeni)	0-10	4.96	3.43	3.08
	10-20	4.30	3.68	2.98
	20-30	4.09	3.24	2.63
	30-40	3.56	2.94	2.57
	40-50	2.93	2.59	2.24
	50-60	2.11	2.17	1.99
	60-70	1.63	1.78	1.63
	70-80	1.06	1.13	0.95

Table 6

Spatial variability of humus content under orchards soil (Central Zone)

Soil Localities	Depth. cm	Humus content. %		
		Row	Technique traces	Spaces between technical traces
1	*2*	*3*	*4*	*5*
Typical chernozem humus moderated (Stauceni)	0-10	3.56	2.83	3.14
	10-20	3.07	2.61	2.73
	20-30	2.91	2.48	2.60
	30-40	2.44	2.26	2.40
	40-50	1.96	1.93	1.94
	50-60	1.47	1.52	1.47
	60-70	1.00	0.98	0.90
	70-80	0.63	0.47	0.42
Typical chernozem humus lower (Cojusna)	0-10	3.20	2.96	2.98
	10-20	2.94	2.70	2.83
	20-30	2.70	2.43	2.68
	30-40	2.41	2.00	2.30
	40-50	2.10	1.88	1.96
	50-60	1.88	1.66	1.80
	60-70	1.43	1.37	1.53
	70-80	0.86	0.63	0.73

With reference to the regime of carbonates there was established between rows in the compacted segments (traces of technique) effervescence line and depth of carbonates. These are found at higher depth than within space between technical traces (tab. 7, 8).

Table 7

Spatial variability of carbonates indices under orchards soil (North Zone)

Soil Localities	Depth. cm	Regime of carbonates indices					
		Row		Technique traces		Spaces between technical traces	
		Efferves cence	Visible carbonates	Efferves cence	Visible carbonates	Efferves cence	Visible carbonates
Typical chernozem humus moderated (Varatic)	0-60		-	-	-	-	-
	60-70	-	-	-	-	+	-
	70-80	+	-	-	-	+	+
	80-90	+	+	+	+	+	+
Typical chernozem humus moderated (Pepeni)	0-50	-	-	-	-	-	-
	50-60	-	-	-	-	+	-
	60-70	-	-	-	-	+	+
	70-80	+	-	-	-	+	+
	80-90	+	+	+	-	+	+
	90-100	+	+	+	+	+	+

Table 8

Spatial variability of carbonates indices under orchards soil (Central Zone)

Soil Localities	Depth. cm	Regime of carbonates indices					
		Row		Technique traces		Spaces between technical trac	
		Efferves cence	Visible carbonates	Efferves cence	Visible carbonates	Efferves cence	Visible carbonates
Typical chernozem humus moderated (Stauceni)	0-30		-	-	-	-	-
	30-40	-	-	-	-	+	+
	40-50	+	+	-	-	+	+
	50-60	+	+	+	+	+	+
	60-70	+	+	+	+	+	+
Typical chernozem humus lower (Cojusna)	0-40	-	-	-	-	-	-
	40-50	-	-	-	-	+	+
	50-60	+	-	-	-	+	+
	60-70	+	+	-	-	+	+
	70-80	+	+	+	+	+	+

In our opinion this phenomenon is due to specific dynamics of bulk density, pore space and depth of percolation. During cold period in soils under self loosening processes caused freezing and thawing and displacement of water flows derived from snow melt favor carbonates leaching. An important role in this regard returns to warming and defrost periods of soils in winter during which dissolution of carbonates is favored by low soil temperatures and water derived from snow melt. Research has shown that during cold period carbonates are alienated from same depth. During vegetation space between rows are differentiated in segments with different degree of surface compaction. In strongly compacted areas (technical traces) even bulk density from surface constitutes 1.35-1.40 g/cm^3 during first half of vegetation period and 1.48-1.52 g/cm^3 during second half. Strong and very strong compacted thickness layer constitutes up to 40-50 cm. In these circumstances during vegetation physical evaporation from compacted surface is very low and that influence carbonate ascension to the surfaceIn row carbonates regime is identical to that from space between technical traces and intensity of physical evaporation from the soil surface is reduces as a result of shading surface of soil. Respectively ascension of carbonates in layer thickness is lower in row than in space between technical traces. Following the exposed we conclude that orchards are characterized by extremely mosaic regime of carbonates with different impacts on processes in the system [CAS] → soil solution, dilution/leaching processes and soil solution, pH values and humification processes (tab. 9, 10).

Table 9

Spatial variability of carbonates content under orchards soil (North Zone)

Soil Localities	Depth. cm	Carbonates content. %		
		Row	Technique trace	Spaces between technical traces
1	*2*	*3*	*4*	*5*
Typical chernozem humus moderated (Pepeni)	0-50	-	-	-
	50-60	-	-	2.90
	60-70	-	-	5.08
	70-80	3.56	-	6.98
	80-90	5.34	3.75	8.14
	90-100	7.29	5.17	10.25
	100-110	9.93	7.43	13.78
	110-120	11.80	9.58	14.59
	120-130	13.87	12.54	12.95

Table 10

Spatial variability of carbonates content under orchards soil (Central Zone)

Soil Localities	Depth. cm	Carbonates content. %		
		Row	Technique trace	Spaces between technical traces
1	*2*	*3*	*4*	*5*
Typical chernozem humus moderated (Stauceni)	0-30	-	-	-
	30-40	-	-	3.48
	40-50	3.27	-	5.86
	50-60	5.64	3.91	8.13
	60-70	8.00	4.89	10.35
	70-80	9.74	7.28	12.68
	80-90	10.28	9.18	13.00
	90-100	12.62	11.53	14.58
Typical chernozem humus moderated (Cojusna)	0-40	-	-	-
	40-50	-	-	3.18
	50-60	3.08	-	4.63
	60-70	4.26	-	6.57
	70-80	5.84	3.71	7.00
	80-90	7.21	6.52	8.30
	90-100	8.60	8.20	10.00
	100-110	10.41	9.83	13.58

At the same time our research showed that specified processes are strongly influenced by particle size composition. It was determined that for soils with loamy particle size composition (Cojusna stationary) these processes keep a quantitative expression lowest than in soils with loam-clay and clay-loamy particle size composition. Against this background calculation indicated a slight dependence between physical clay content (< 0.01 mm) and proportion of carbonates dynamics. Among the fine clay content and carbonates migration does not outlined any dependence. Structuring process under orchards are maintained as black field that determine practiced agro-technical measures and self structure processes determined by volumetric changes which come from moistening and drying processes; freezing and thawing, inflation-contraction. Previous research has been established that structure is correlated with compaction process and evolution of structural-aggregation state determined by boulders and spraying structure processes, as well by compacting processes of structural aggregates. Process boulders leads to increased contend of aggregates >5 mm. This process affects mainly space between rows. Soils in rows practically are not subjected to process of boulders. Maximum this processes affects spaces under compaction influenced by agricultural machinery. Within these structure boulders is found up to 60 cm. The aggregate content >10 mm is more than 30 %. In the space between technical traces boulders processes decreased significantly (aggregates content >10mm ranges from 15 to 20 %). In contrast there are developed intensive spraying structure processes by increasing aggregates content <1 mm particularly 0.5-0.25 şi < 0.25 mm. Spraying is caused maintenance work under orchards which affect predominantly arable layer 0-10 cm. Spraying phenomenon of structure is related to increased intensity of crusting processes that leads to the formation of a consolidated crust on soil surface with a thickness 8-12 cm. Their further detachment is through agrotechnical operations or excessive moisture in some periods of year which intensify over time the effect of spray structure.

Research has shown compaction practically does not affect aggregates > 7 mm. Maximum are affected by compaction process aggregates 3-0.5 mm. Compaction process is quantitative expressed in compacted segment. In space between traces frequently it is found a substrate (ranges at dept 5-10 cm) with maximum degree of aggregates compaction. Compaction of aggregates is accompanied by volume and diameter reduction of aggregates pores which lead to a reduction of moisture in conductors pore volume. At the same time high weight of aggregates formed in the tillage process lead to significant reduction of soil aggregates stability.

Specified processes lead to reduction of soil biological activity: cellulose decomposition, production of $N\text{-}NO_3$, CO_2 and phosphorus mobilization. Reduction of biological activity is accompanied by significant diminution in soil of transformational capacity. In special for orchards it has extremely serious consequences if it takes into account fact that they use large quantities of phytosanitary products. Some of these substances fall into soil and the ability to change transformational capacity is low because they are accumulated in root layer and cause technochemical tiredness of soil. The processes described are favored significantly by reduced reserves of fresh organic matter and humus accumulation in soil, aggregate stability reduction, aggregates compaction, permeability reeducation for water and hydraulic conductivity. From this point we consider that pedogenesis processes management in orchards implies mandatory enrichment of soils with organic matter and optimization of conditions for decomposition, transformation and humification by avoiding physical degradation of soils. This would require substitution of anthropogenic factors with biogenic factors which suppose transferring orchards based on biogeocenological processes.

CONCLUSIONS

Orchards are particular agricultural landscapes which differ from other agricultural and natural spaces through process of pedogenesis particularities which are determined by specific regimes, airhydric and hydrothermal that conducts to modification of elementary pedogenesis processes in chernozems type. In addition soil evolution within orchards is influenced by processes of alcalinization in soil solution and transformational capacity reduction.

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