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POSTAGROGENIC EVOLUTION OF CHERNOZEMS IN FALLOW CONDITIONS

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Abstract

The research in the pilot lands showed a change of chernozems from arable regime to fallow regime involves initiating a new postagrogenic phase of development. The basic components of postagrogenic evolution are restoration system of soil organic substances, porous space recovery, increase capacity for water and water reserves.

Key words*: postagrogenic evolution, humifiable organic matter, labile humic substances, aggregate composition, porous space.*

INTRODUCTION

The periods of crisis in agriculture has always been involving the leave of less productive lands and leave them fallow.

Social and economic changes that took place in between the Prut and Dniester rivers space in the late twentieth century beginning of twentieth first century cited radical changes in the agricultural use of soil resources.

Referred to this chapter is the exclusion of the arable lands from agriculture, and leaveing them fallow.

The investigation of the processes which is realized in soils under fallow conditions presents both, scientifical and practicalal interest, particularly related to forecasting the evolution.

Based on the theory of pedogenesis the transition of arable fallow land involves restoring in time of the place and biological role factor in functioning the soil ecosystem. In this regard, land fallow involves restoring the composition and volume of biological circuit substances and autorehabilitation of feature and and soil regimes:

In Russia, in between the eighteenth and nineteenth centuries was practiced the periodic passage of land fallow to restore the depleted soils. According to V.R.Williams in the first year after fallow maintenance the wheat yields 6-10 t/ha and the content protein substances in grain made up more than 30% (Williams, 1936).

At the same time, P.A.Kostacev, still in the second half of the nineteenth century considered fallow maintenance of soils contribute to amelioration of the restoration of characteristics and soil regimes.

Recent research has shown that in the remaining fallow land the occurs the development of successively several associations of grass plants, including until the rehabilitation of regional plant formation.

According to many authors in soils in the fallow areas it creates a string of restoration and balance directions of the biogeochemical composition circuit of substances and ensure renaturation and enlarged reproduction of the type (subtype) zonal pedogenesis.

The data of Cadastre of the Republic of Moldova for the last 20-25 years shows a significant increase of fallow surfaces, which involves several economic and environmental issues. The purpose of the research involved studying the direction, intensity and dynamics evolution of tipogenetic black soil processes integrated in the process of restoring the fallow landscape.

MATERIALS AND METHODS

The research was conducted in pilot lands in southern (Cantemir) and central (Chisinau) areas of Moldova and included field and laboratory applications.

Field applications included the opening of soil profiles in the width of 8-10 m after morphometric measurements were collected soil samples taking into account the variability in space of morfometrical features. For each profile there were collected 5 sets of individual samples over the entire thickness thereof taking into account the thickness and sequencing of the horizons. Subsequently the samples were mixed in order to obtain a sample with one composition for each depth (horizon).

For laboratory research were used the following methods.

1. Determination of humus - ȚINAO method.
2. Determination of total nitrogen – ȚINAO method.
3. Determination of apparent density - Kacinschi method.
4. Determination of composition aggregation and water stability aggregation - Savinov method.
5. Determination of peptiser clay in water - Gorbunov method.
6. Determination of hydro indices - based on suction curve.

Labile fraction of humic substances extracted using 0.1N NaOH is and subsequent determination of the carbon content was performed by the ȚINAO method.

The total porosity was calculated by applying the formula:

$$Et = \left(I - \frac{Pb}{Ps} \right) x100$$

where,

Et – total porosity, - %;

Pb – bulk density, g/cm^3;

Ps – solid phase density, g/cm^3.

RESULTS AND DISCUSSIONS

Among the first features that react to the chage from chernozems to fallow are morphometric traits. In this context worth to mention that in less than 10 years in the segment of the soil surface the fallow horizon is forming. The horizon color becomes black, the compactness and structure of the high-profile is improving, practically, the agrogenic features disappear completely.

The maintenance of chernozems under fallow regime leads to the restoration and balance the system of organic matter in the soil.

An important index characterizing organic substances system is non-humifiable organic matter content (detrit humus) in the soil.

It is known that placing the chernozems in arable circuit involves the destruction of the humus detrit layer (Jigau, 2009). In addition, the annual plowing of the arable layer leads to an accelerated mineralization of the non-specific organic matter present in soil. The passage of soils from arable under fallow regime is accompanied by a slow increase of non-humifiable organic matter in the soil (Table 1).

Table 1. The dynamics of non-humifiable organic matter in typical chernozem with poor humus in various maintenance regimes (SRL Podgoreni, Cantemir rayon), % (July)

Depth, cm	Soil maintance regime											
	Plow			Mini-Till			Fallow			Forest shelterbelt		
	2011	2012	2013	2011	2012	2013	2011	2012	2013	2011	2012	2013
0-10	0.08	0.08	0.11	0.24	0.41	0.56	1.57	1.77	1.77	1.92	1.93	1.95
10-20	<0.01	0.03	0.02	0.22	0.25	0.28	0.23	0.37	0.41	0.73	0.73	0.79

From the above table we can notice that under typical plowing system of chernozem in southern Moldova that practically the non-humifiable debris are not present. Reducing the cultivation works is increasing the non-humifiable organic matter content in soil.

From the above table we can see that in conditions of Mini-Till System it establishes a stable increase of non-humifiable organic matter content.

The biggest content of non-humifiable organic matter in soils is found in forest shelterbelts.

This content is relatively stable and varies in the range of 1.92-1.93% of 0-10 cm layer. In the 10-20 cm layer the non-humifiable organic matter content decreases abruptly in the range of 0.73-0.79%.

In fallow soils in 0-10 cm layer is establishing a cumulative trend of non-humifiable organic substances. Its content in the layer 10-20 cm indicates a clear cumulative regressive distribution. However, given the fallow age (12 years) we can conclude that the accumulation of non-humifiable soil organic matter results more intensive than in forest shelterbelt (age 53 years). According to the calculations during the 12 years the amount of debris has increased from 3.27 to 11.02 t/ha. The percentage of root residues increased from 11.3 to 43.6%.

The slow restoration of non-humifiable organic matter reserves contributes to unidirectional process of formation and accumulation of humus (Table 2).

Table 2. Indices of restoring the humus profile of typical chernozem poor in humus (SRL Podgoreni, Cantemir) under various conditions of maintenance

Maintainance system	Depth cm	Year								
		2011			2012			2013		
		Total Humus %	Mobile Humus %	% humus mobile from total humus	Total Humus %	Mobile Humus %	% humus mobile from total humus	Total Humus %	Mobile Humus %	% humus mobile from total humus
Plow	0-20	3.6	0.14	3.8	3.6	0.11	3.0	3.6	0.13	3.6
	20-40	3.3	0.06	1.8	3.3	0.06	1.8	3.3	0.04	1.2
	40-60	2.4	0.03	1.2	2.4	<0.03	<1.2	2.4	<0.03	<1.2
Mini-Till	0-20	3.9	0.15	3.8	3.9	0.13	3.3	4.0	0.15	3.8
	20-40	3.3	0.08	2.4	3.3	0.08	2.4	3.5	0.10	3.1
	40-60	2.4	0.04	1.7	2.4	0.04	1.7	2.4	0.04	2.4
Fallow	0-20	4.4	0.32	7.2	4.4	0.28	6.3	4.4	0.36	8.2
	20-40	3.6	0.14	3.8	3.6	0.12	3.3	3.6	0.15	4.1
	40-60	2.8	0.09	3.2	2.8	0.09	3.2	2.8	0.12	4.1
Forest shelterbelt	0-20	4.7	0.38	8.0	4.7	0.33	7.0	4.7	0.39	8.2
	20-40	3.9	0.13	3.3	3.9	0.10	2.5	3.9	0.15	3.9
	40-60	3.3	0.11	3.0	3.3	0.09	2.6	3.3	0.13	3.9

In this regard, it is mentioned that under fallow conditions the formation and accumulation process and helps restore, in particular, the humus profile, and in general the humic substances profile.

From the above table we can see that under fallow conditions increases the humus content not only in the first 0-20 cm but also in deeper layers. The obtained data showes the distribution of humus in the first 0-60 cm the soil within this treatment is significantly different from the plowing treatment approaching to initial version that is typical to forest shelterbelts.

Even more significant changes occurred in the case of labile fraction.

From the presented table can be seen that under fallow conditions significantly increases the processes of decomposition and transformation of debris into stable humus fraction, which helps to restore soil humus reserves and labile fraction of humic substances that contribute to increase the soil fertility.

Also it should be mentioned that the process of humus formation in fallow chernozems is accompanied by enriching the humus with nitrogen.

According to Table 3 it can be found that under arable regime, during the years 1975-2012 –

the total content of carbon was reduced to 0.7-0.8% in arable layer (about 4/3 of the initial content) and total nitrogen content decreased almost twice. In arable layer it decreased from 0.23 to 0.12-0.13%.

Following the C:N ratio it has increased from 11.3-11.8 to 14.6-15.8. This allows us to conclude that dehumification, under arable regime, involves mineralization of fraction of the humic substances rich in nitrogen. At the same time, under pronounced shortage of biological nitrogen the humification process results in the formation of humic substances poor in nitrogen.

The passage of chernozems from arable to fallow regime leads to the restoration process of formation and accumulation of humus. At the same time, there is humus nitrogen enrichment, which allows us to conclude that in terms of postagrogenic conditions of evolution leads to formation of high quality mature humus.

Increasing the humus content in chernozems leads to an improved potential of their's structure.

The data presented in Table 4 is showed that under arable regime, after a period of time the reductions of humus reserves in soil increases in the same time the ratio clay: hummus (A: H), this indicates the capacity reduction of aggregation. This is materializes in increasing the content of fine clay peptised in water and factor of disperssion (Tabel 5). Increasing the content of humus in fallow conditions, on the contrary contribute to reduce the content of fine clay peptised in water, respectively, to reduce the coefficient of dispersion (Table 5).

The increase of the capacity of aggregation leads to intensification of structure process. The data presented in Table 6 shows that from 2003 to 2012 the content of aggregation agronomic valuable has increased on average by 5% in the layer of 0-20 cm and 6-10% in 20-50 cm layer. The coefficient of structure (Ks) in 2012 compared to 2003 increased in average 1.3-1.5 times. At the same time, in soils there is a stable trend of increasing the water stability structure. As a proof, significantly increases the ratio of the total aggregate 10-0.25 mm and content of those water stabile (Table 6).

Significant changes showes the hydrophysical indices (Table 7).

The accumulation of organic matter in the soil leads to the slow change in the solid phase density values. More pronounced is the reduction of these values in the first 0-30 cm from the surface and is well correlating with the evolution in time of organic matter content.

Improving the structural-aggregate situation leads in time to architectural changes of agrogenic layer, combined with reduced soil bulk density. These changes are more pronounced in the 0-50 cm layer which leads to a decrease to the minimum of agrogenic stratification of soil profile. In the latter the bulk density values slightly increases with depth.

Synchronized with the evolution of soil density it is the evolution of spatial porosity.

In Table 7 it is showed that in 2003 the investigated soils had discontinuous porous space, which is determinated by the unsatisfactory values of total porosity of the sub- arable layer (30-40 cm).

Already in 2009 the discontinuity of porous space is reduced to a minimum and by 2012 for the studied chernozems is characteristic a porous profile that is very close to natural state.

Specified changes have a small influence on the hygroscopicity coefficient (CH) and fading coefficient (CO). However, it significantly influence the field capacity to ensure increasing its values and homogenization of hydrophusical profile. As a result it increases the water storage in soil and accesible water reserves (SAD). All these contribute to recover soil functionality, renaturation and enlarged reproduction of the formation of chernozem type soil.

Table 3. Evolution of indices of typical chernozem humus enrichment with nitrogen in various maintenance conditions (release from the archive of Republican Centre of Applied Soils)

Depth, cm	Arable												Fallow								
	1975			1990			2003			2012			2003			2009			2012		
	C	N	C:N	C	N	C:N	C	N	C:N	C	N	C:N	C	N	C:N	C	N	C:N	C	N	C:N
0-10	2.7	0.23	11.8	2.2	0.17	12.9	2.0	0.14	14.3	1.9	0.13	14.6	1.9	0.13	14.6	2.2	0.19	11.6	2.4	0.21	11.4
10-20	2.6	0.23	11.3	2.1	0.16	13.1	1.9	0.13	14.6	1.9	0.12	15.8	1.9	0.12	15.8	2.0	0.17	11.8	2.2	0.19	11.6
20-30	2.3	0.20	11.5	2.0	0.14	14.3	1.6	0.11	14.5	1.7	0.11	15.4	1.7	0.11	15.4	1.7	0.16	10.6	2.0	0.18	11.1
30-40	1.5	0.08	18.8	1.5	0.08	18.8	1.5	0.08	18.8	1.5	0.08	18.8	1.5	0.08	18.8	1.6	0.13	12.3	1.8	0.16	11.3
40-50	1.0	0.05	20.0	1.0	0.05	20.0	1.0	0.05	20.0	1.0	0.05	20.0	1.0	0.05	20.0	1.0	0.08	12.5	1.0	0.09	11.1

Table 4. Distribution of clay (A), humus (H) and ratio of clay: humus (A: H) within the typical chernozem profile before and after fallow

Depth, cm	Arable regime												Fallow								
	1975			1990			2003			2012			2003			2009			2012		
	A	H	A:H	A	H	A:H	A	H	A:H	A	H	A:H	A	H	A:H	A	H	A:H	A	H	A:H
0-10	45.8	4.6	10.0	45.2	3.7	12.2	45.2	3.3	13.6	45.1	3.3	13.7	45.1	3.3	13.7	45.8	3.8	12.1	45.8	4.2	10.9
10-20	45.7	4.4	10.4	45.5	3.6	12.6	45.5	3.4	13.4	45.5	3.2	14.2	45.5	3.2	14.2	45.6	3.5	13.0	45.6	3.8	12.0
20-30	48.5	2.6	18.7	48.4	2.7	17.9	48.4	2.7	17.9	48.4	2.8	17.3	48.4	2.8	17.3	48.4	2.8	17.3	48.4	3.1	15.6
30-40	48.4	1.8	26.9	48.4	1.8	26.9	48.4	1.8	26.8	48.4	1.8	26.9	48.4	1.8	26.9	48.4	1.8	26.9	48.4	1.8	26.9
40-50	49.6	1.4	35.4	49.7	1.4	35.5	49.7	1.3	38.2	48.7	1.3	37.5	48.7	1.4	37.5	48.7	1.4	34.8	48.7	1.5	32.5
80-90	46.2	1.1	42.0	46.0	1.1	41.8	46.8	1.1	42.5	46.8	1.1	42.5	46.8	1.0	46.8	46.8	1.2	39.0	46.8	1.2	39.0

Table 5. The content of fine clay (<0.001 mm) peptised in water and factor of dispersion of the typical chernozem before and after fallow

Depth, cm	Content of peptised clay, %						Factor of dispersion, %					
	Arable				Fallow		Arable				Fallow	
	1975	1990	2003	2012	2009	2012	1975	1990	2003	2012	2009	2012
0-10	2.9	3.3	3.5	3.6	2.4	2.2	9.7	10.2	12.6	14.9	11.3	9.6
10-20	2.8	3.4	3.4	3.5	2.4	2.3	9.7	10.4	14.4	16.8	12.1	9.5
20-30	2.9	3.3	3.4	3.6	2.6	2.3	9.6	10.8	13.9	16.9	12.4	9.5
30-40	3.1	3.2	3.3	3.5	2.7	2.6	9.9	10.9	12.5	15.3	13.6	9.7
40-50	3.3	3.3	3.2	3.2	3.1	3.0	10.4	10.2	12.3	14.9	13.8	9.9
50-60	3.4	3.4	3.4	3.2	3.1	3.1	11.7	12.2	12.2	13.9	13.9	11.4
70-80	3.1	3.0	3.0	3.0	3.3	3.2	13.8	13.6	13.8	14.0	14.0	13.8

Tabel 6. Evolution of aggregate composition of typical chernozem under fallow regime

Depth, cm	Content of aggre-gation agronomic valuable (10.0-0.25 mm), % (dry fraction)		Coefficient of structure (Ks)		Content of aggre-gation agronomic valuable water stabile, % (humid fraction)		Criterion of water stability, % (Kc)	
	Content	Specifi-cations	Ks	Specifi-cations	Content	Specifi-cations	Ks	Specifi-cations
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
2003								
0-10	65.69	good	1.93	good	52.30	good	87	quite good
10-20	59.08	quite good	1.44	good	58.92	good	161	good
20-30	63.78	good	1.76	good	54.76	good	117	good
30-40	64.53	good	1.83	good	54.00	good	114	good
40-50	60.18	good	1.45	good	52.71	good	87.0	quite good
2009								
0-10	67.96	good	2.12	excellent	54.62	good	108	good
10-20	66.60	good	1.80	good	64.41	good	149	good
20-30	67.80	good	2.10	excellent	57.57	good	143	good
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
30-40	67.80	good	2.10	excellent	57.70	good	126	good
40-50	67.25	good	2.05	excellent	56.53	good	133	good
2012								
0-10	70.64	excellent	2.48	excellent	56.93	good	121	good
10-20	74.12	excellent	2.86	excellent	69.90	good	155	good
20-30	71.73	excellent	2.54	excellent	60.38	good	172	good
30-40	70.83	excellent	2.41	excellent	59.37	good	137	good
40-50	71.4	excellent	2.53	excellent	60.00	good	176	good

Tabel 7. Evolution of agro-physical characteristics of typical chernozem under fallow conditions

Depth. cm	Density g/cm^3		Total porosity, %	Moisture during sampling	Agro-physical indices, % g/g			
	Solid phase	Apparent			CH	CO	CC	DAU
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
2003								
0-10	2.55	1.02	60.0	14.55	10.7	13.9	32.6	18.6
10-20	2.57	1.13	56.0	17.75	11.1	14.3	32.2	17.9
20-30	2.59	1.23	52.0	18.96	10.9	14.8	30.3	15.5
30-40	2.60	1.34	48.0	18.38	10.6	14.5	28.5	14.0
40-50	2.62	1.32	50.0	19.96	10.6	14.5	29.8	15.3
50-60	2.63	1.27	52.0	17.31	10.4	14.5	30.5	16.0
60-70	2.65	1.29	51.0	16.98	10.6	14.5	30.8	16.3
70-80	2.67	1.31	51.0	16.94	10.1	13.0	30.1	17.1
80-90	2.67	1.34	50.0	16.92	9.8	13.2	29.4	16.2
90-100	2.69	1.40	46.0	16.92	9.7	13.1	28.1	15.0
2009								
0-10	2.53	1.00	60.0	18.65	10.5	13.4	35.3	21.9
10-20	2.54	1.05	59.0	20.68	10.9	14.0	36.9	22.9
20-30	2.56	1.19	54.0	21.87	11.2	14.3	34.4	20.1
30-40	2.58	1.27	51.0	24.32	10.7	14.8	32.5	17.7
40-50	2.59	1.30	50.0	23.59	10.6	14.6	33.1	18.5
50-60	2.60	1.28	51.0	24.78	10.6	14.5	31.2	16.7
60-70	2.63	1.29	54.0	22.81	10.4	14.5	30.6	16.1
70-80	2.66	1.31	51.0	19.63	10.4	13.0	30.3	20.3
80-90	2.67	1.34	50.0	18.29	10.1	13.0	29.5	16.5
90-100	2.69	1.39	48.0	18.37	9.9	12.9	28.7	15.8
2012								
0-10	2.50	0.93	63.0	23.87	10.4	13.4	36.3	22.9
10-20	2.52	1.02	60.0	25.48	10.9	13.9	38.1	24.2
20-30	2.53	1.11	56.0	25.90	11.3	14.0	34.9	20.9
30-40	2.57	1.18	54.0	25.96	10.9	14.4	33.8	19.4
40-50	2.59	1.27	51.0	26.14	10.7	14.6	33.4	18.8
50-60	2.60	1.28	51.0	25.91	10.6	14.8	32.9	18.1
60-70	2.63	1.29	51.0	23.78	10.6	14.5	30.6	16.1
70-80	2.66	1.31	51.0	20.93	10.4	13.9	30.3	16.4
80-90	2.67	1.34	50.0	20.89	10.1	13.3	29.5	16.2
90-100	2.69	1.39	46.0	20.37	10.1	12.9	28.7	15.8

CONCLUSIONS

By the theory of pedogenesis the transition of chernozems from the fallow to arable regime involves over a spcifica amount of time, restoring the place and role of biological factor in soil ecosystem in order to function and initiate the evolution of postagrogenic soil ecosystem.

Basic components of postagrogenic evolution are:

a) restoring the organic matter in the soil system

b) formation and accumulation of humus

c) structuring and aggregating the soil substance

d) recovery the porous space, increasing the capacity for water and acccesible water reserves in soil.

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