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THE PEDOFUNCTIONAL FRAMEWORK FOR ENSURING ADAPTIVE-LANDSCAPE-AMELIORATIVE TECHNOLOGIES

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Abstract

The evolutionary trends of arable chernozems are determined as result of series of integrated agrogen processes with natural processes and typogenetic, and exodynamic (destructive) processes. In contrast to the natural processes, the agrogen does not bear a temporary character – cyclic, reversible but are unidirectional progressive over time. As consequences their intensification minimized the weight of natural processes, which leads to equilibrium disturbance between the components of agrolandscapes. Under these conditions establishing the natural trend of soil ecosystem functioning in its basic quality as agrolandscape can be achieved only within a new advanced type, adaptive-landscape-ameliorative agricultural systems.

Key words*: arable chernozems, agrogen processes, agrolandscape, natural trend.*

INTRODUCTION

According to recent evaluation over 80 per cent of arable chernozems are affected by 2-3 anthropogenic processes including destructuring, compaction, decreasing in humus content. Rapidly are extended surfaces affected by secondary over wetting in some periods of year. Practically all soil resources are affected by energetic and biologic degradation. Therefore, experienced effects in over cultivation chernozems materialized in reduction to minimum capacity of self-reproduction and self-regulation of soil ecosystem with involvement of aridization-desertification elements. Soils affected by specified processes practically are no longer responsive to agrotechnical and agrochemical applied measures. At the same time, it is only partially exploited agroclimatic potential of the landscape and the capacity of agroecosystems adaptation to drought and extreme temperatures. To the contrary increased vulnerability degree of agroecosystem to climate instability, for that crop remain fully dependent on climatic conditions.

Taking into consideration the mentioned, we can conclude that despite the material and financial efforts submitted, agricultural systems applied not only do not ensured enhancing of soil fertility, as was stated during the last 50-60 years but also have led to deregulation stability of landscape with damage to environment components. This implies the need to promote and implement new agricultural systems based on the harmonious combination of society's interest and laws of development.

MATERIALS AND METHODS

Methodological framework of some integrated technologies in the functioning mechanisms of landscape (ecosystems) is provided by the concept of sustainable agriculture that is based on sustaining the natural process of soil as the basis of landscape. From this perspective of ideas the sustainable use of soil resources is not conceivable without properly addressing landscape-ecological complex process of territorial organization to agricultural production and its management. The agricultural systems should be developed based on the legalities and fundamental principles of landscape functioning and are called to ensure the exclusion of disturbing risks of state and equilibrium of natural systems used in agriculture. This situation can be provided by adaptive-landscape agricultural systems. However, where quasi-equilibrium state is deregulated, should be practiced agricultural systems able to provide rehabilitation. Starting from the real state of soil resources used in agriculture, we consider that the concept of landscape adaptation is outdated.

The object of restoring the natural trend of soil ecosystem functioning in his basic quality as agrolandscape, can be achieved under a new more advanced type adaptive-landscape-ameliorative agricultural systems.

In accordance with the exhibited objectives which focus on the priority directions of sustainable management for soil resources are the:

- Rational correlation of objectives for the use of soil resources, including investment programs, with potential and capacity to sustain the natural capital (principle of adaptation);
- Anticipation of climate change effects and development of action plans for crisis generated by natural phenomena and anthropic.
- Ensuring food security, food safety and economic prosperity through harnessing the benefits of soil resources in Republic of Moldova, without compromising the need to maintain soil fertility, biodiversity conservation and environmental protection.

In developing the present paper have been used own research results and also materials obtained under soils evaluation investment for the purpose of implementation of adaptive-landscape-ameliorative technologies.

RESULTS AND DISCUSSIONS

The bioclimatic conditions of Republic of Moldova favors as priority achievement three typogenetic regional processes: the formation and accumulation of humus, structure and accumulation of carbonates. The contrasting characters determine the temperature regime at regional level, the argillic alteration which ensures the stability of soil particle size composition. Combining efficiently these processes in strict accordance with specific landscape conditions ensuring stability and enlarged reproduction, over time (at pedological scale) of the chernozem type pedogenesis. The large diversity of climatic and geomorphological conditions determines three levels of fertility and respectively, chernozems functioning under region (Tables 1, 2, and 3).

Along with natural typogenetic processes in the contemporary evolution of chernozems in region, these also are influenced by a series of agrogen and degradative processes (Table 4).

Synchronized development of natural processes with agrogen and degradative lead to diversification of pedogenetic regional process with involvement of several natural and anthropic evolution forms (Jigau, 2008; Lesanu and Jigau, 2012).

Table 1. The parameters of agrophysic structural-functional model of chernozems in the space between Prut and Nistru

Fertility factors	Normative for fertility levels		
	Reduced	Moderated	Increased
Aggregate composition:			
- Physic clay content (< 0.01 mm), %	15-30	30-45	45-60
- Fine clay content (< 0.001 mm), %	12-18	20-30	30-40
Microaggregate composition:			
- microaggregate content > 0.01 mm, %	65-70	70-82	>82
- clay peptizer content (< 0.001 mm), %	3-4	2-3	1-2
Structural composition:			
- aggregate composition 10-0.25 mm, %	65-70	70-80	>80
- aggregate stability (hydrostable aggregates > 0.25 mm), %	<40	40-60	>60
The coeficient of dispersion, %	25-40	15-25	<15
Degree of aggregation, %	50-65	65-80	>80
Coefficient of structure	<0.67	0.67-1.5	>1,5
Bulk density, g/cm^3	<1,0	1.0-1.1	1.1-1.3
Resistance to penetration, kg/cm^2	>50	26-50	<25

Table 2. The parameters of hydrophysic structural-functional model of chernozems in the space between Prut and Nistru

Fertility factors	Normative for fertility levels		
	Reduced	Moderated	Increased
The average permeability for 6 hours, mm/hour	<25	25-35	35-40
Field capacity for water, %, g/g	<25	25-30	<30
Total porosity, %	<50	50-55	55-65
Capacity for air, %	12-15	15-20	20-25
Conductive pore of moisture, % of total porosity	<40	40-55	55-65
Inaccessible water content, %, g/g	>13	11-13	<11
Reserves of productive water, layer 0-100 cm, mm	<180	180-200	>200

Table 3. The parameters of physic-chemical structural-functional model of chernozems in the space between Prut and Nistru

Fertility factors	Normative for fertility levels		
	Reduced	Moderated	Increased
Humus content in the horizon Am, %	<4	4-6	>6
Layer thickness of humus generating horizon (A+AB), cm	<60	60-80	>80
The reserve of humus t/ha, layer 0-100 cm	<350	350-500	>500
Ratio C:N in composition of humus	>13:1	10-13:1	10:1
Ratio Ca:Mg adsorbed in radicular layer	<10:1	10-13:1	13-14:1
Cacium content adsorbed, % of the cation exchange capacity	<70	70-80	>80
Degree of base saturation, %	<80	80-95	≈100
Content of mobile phosphorus, mg/100 g soil (annual crops)	1.6-3.0 (2.1-3.5)	3.1-4.5 (3.6-5.0)	4.1-5.0 (4.6-6.0)
Content of mobile phosphorus, mg/100 g soil (vineyards plantations)	3.1-4.5	4.6-6.0	6.1-8.0
Content of mobile phosphorus, mg/100 g soil (fruit plantation)	<3.0	3.0-4.0	>4.0
Exchangeable potassiun content, mg/100 g soil (annual crops)	10.1-20.0	20.1-30.1	30.1-40.0
Exchangeable potassiun content, mg/100 g soil (vineyards plantations)	8,1-12,0	12.1-18.0	18.1-25.0
Exchangeable potassiun content, mg/100 g soil (fruit plantation)	10.0-20.0	20.1-30.0	>30
Content type of mobile zinc, mg/kg	0.31-0.9	0.91-1.5	1.51-4.5
Content type of mobile copper, mg/kg	0.11-0.3	0.31-0.7	0.71-2.1
Content type of mobile manganese, mg/kg	15-25	25-40	40-80
Content type of boron manganese,, mg/kg	0.31-0.9	0.91-1.2	1.21-3.6
Adsorbed sodium content, % of total capacity of the cation exchange capacity	5-10	3-5	<3.0
pH	>7-8	7.2-7.8	6.8-7.2

Table 4. Contemporary evolutionary processes of chernozems in the Carpato-Danubiano-Pontic space

Class	Group	Elementary processes
Natural	Bioclimatic (typogenetic)	Formation and accumulation of humus Structuring Migration of carbonates
	Sinevolutionary	Eluvial, levigation, debasification, argilization
	Functional	Decomposition and synthesis of organic substances Decomposition and synthesis of minerals Biologic accumulation of biofile elements Differentiation of substances Haploidization
Agrogene	Morphoturbational	Stratification, compaction, destructuring, plagenization and slitization
	Turbational regime	Crusting, peptization, siltization (clogging), over wetting, aridization
	Functional turbational	Dehumification, depletion, exhuastion, overcultivation, pollution reduction / degradation of soil biota biodiversity
Degradative	Abrazional	Erosion Deflation (wind erosion)
	Destructive	Landslide and land subsidence Flooding Pedolit accumulation

Modifications specified are materialized in the noticeable morphologic modifications and morphogenetic as opposite to natural processes, the anthropogenic does not bear temporary character – cyclic reversible but are unidirectional progressive over time remaining effects are cumulated. In the early stages these are localized in the upper segment of profile. Thereafter extending in the lower horizons and certified across the active pedogenetic segment.

Therefore in agroecosystems (agrolandscapes) the pedogenetic ambiance is determined by the ratio between the impact of natural and anthropogenic factors. Last are materialized in processes (destructuring, compaction, crusting and clogging) leading to imbalance ratio between biotic and abiotic factors, respectively deregulation of structural-functional organization resulted in the formation of new types of functional profiles that do not have natural analogues (Table 5).

Table 5

Types of agrophysic profiles of chernozems in the anthropogenic pedogenesis

Types of agrophysic profiles	Depth, cm	Bulk density		Apparent porosity		Aeration prosity	
		g/cm^3	specification	%	specification	%	specification
Excessive loosening	0-10	0.87	Unsatisfactory	76	Excessive	43	Excessive
	10-20	0.91	Unsatisfactory	73	Excessive	39	Excessive
	20-30	1.02	Optimal	60	Excellent	31	Excessive
	30-40	1.07	Optimal	58	Excellent	28	Admissible
	50-60	1.14	Optimal	57	Excellent	24	Optimal
Loosening	0-10	1.02	Optimal	60	Excellent	30	Admissible
	10-20	1.07	Optimal	59	Excellent	30	Admissible
	20-30	1.03	Optimal	59	Excellent	29	Admissible
	30-40	1.17	Optimal	55	Excellent	23	Optimal
	50-60	1.14	Optimal	57	Excellent	23	Optimal
Epicompacted (crust)	0-10	1.52	Siltic	40	Extreme insufficient	14	Insufficient
	10-20	1.46	Consolidated	43	Insufficient	13	Insufficient
	20-30	1.34	Critique	48	Insufficient	13	Insufficient
	30-40	1.21	Optimal	47	Insufficient	15	Sufficient
	50-60	1.15	Optimal	56	Excellent	17	Sufficient
Proxycompacted	0-10	1.24	Optimal	51	Sufficient	23	Optimal
	10-20	1.50	Slitic	41	Insufficient	13	Insufficient
	20-30	1.43	Unfavorable	44	Insufficient	13	Insufficient
	30-40	1.47	Consolidated	43	Insufficient	11	Insufficient
	50-60	1.19	Optimal	54	Sufficient	17	Insufficient
Mezocompacted	0-10	1.27	Optimal	51	Sufficient	20	Optimal
	10-20	1.27	Optimal	41	Sufficient	20	Optimal
	20-30	1.55	Slitic	40	Extreme insufficient	13	Insufficient
	30-40	1.21	Optimal	54	Sufficient	16	Sufficient
	50-60	1.40	Critique	47	Insufficient	15	Sufficient
Baticompacted	0-10	1.08	Optimal	58	Excellent	37	Excessive
	10-20	1.22	Optimal	53	Sufficient	28	Admissible
	20-30	1.20	Optimal	54	Sufficient	26	Admissible
	30-40	1.24	Optimal	53	Sufficient	25	Optimal
	50-60	1.50	Slitic	43	Insufficient	14	Insufficient
	70-80	1.50	Slitic	40	Extreme insufficient	12	Insufficient

In the excessively loosening profile are created favorable conditions for water storage. At the same time, excessive aeration porosity in 0-30 cm layer causing low capacity for useful water in the soil. As result in these soils with agrophysics profile the water scarcity and pedological drought under pedogenetic active layer is attested in the years with the natural atmospheric precipitation regime. Soils with agrophysics profile, epicompacted and proxycomapcted have low and very low water permeability. Consequently this store only about 40 % of precipitation that is why here is attested unsatisfactory water reserves (< 80 mm in the 0-100 cm) even at the beginning of vegetation period. However, in these conditions is forming poorly developed radicular systems. Soils with mezocompact profile favor the development of a well-developed radicular system. The presence of slitic layer at the depth 20-30 cm causes the concentration of water, nutrients and plant roots in the first 20-30 cm. Thus in years with normal precipitation harvest are limited to the capacities of 0-30 cm segment. In dry years the pedologic drought in soils already occurs in June. In the soils with baticompacted agrophysics profile the edaphic volume is good. In the 0-50 cm layer is created normal conditions for radicular system development. However, excessive aeration porosity causes the losing party of the water reserves to physical evaporation. At the same time the presence of slitic layer in the middle segment of profile (50-60 cm) does not allow the water reserves and nutrients exploitation in the medium and lower segment of profile.

Table 6. Criteria for evaluating the degree of resistance

Nr.	Criteria for evaluating the agrolandscape			Specification
1.	BH ≥ 0 H ≥ 5 % GCN = 100% GCP = 100 % GCK = 100% Nm – raised K_2O ≥ 30 mg/100g P_2O_5 ≥ 4 mg/100g	CSC ≥ 30 me/100g pH – neutral, weakly basic Ca:Mg 9-10:1 Na me/100 g < 1 SA < 0.15-0.25 %	AAV>80 % DA = 1.1-1.38 g/cm^3 Ɛt = 55-65 % Ɛair = 15-25 % Ɛagr = 55-65 % Kstr > 1.5 AHS > 60 %	Anthropogenic pressures correspond to reproductive capacity of landscape. The agrolandscape stability constitutes about 100 %. Conservation measures are needed for landscape.
2.	BH < 0 H =4-5 % GCN ≥ 90% GCP ≥ 95 % GCK ≥ 80% K_2O = 25- 30 mg/100 g P_2O_5 = 3.3-3,4 mg/100g	Nm – moderated pH – weakly basic, basic Ca:Mg 7-9:1 Na me/100 g < 1 SA < 0.15-0.25 %	AAV=60-80 % DA = 1.3-1.4 g/cm^3 Ɛt = 50-55 % Ɛair = 25-30 % Ɛagr = 20-25 % Kstr = 1.0-1.5 AHS =50-60 %	Compliance degree of anthropogenic pressures and landscape capacity constitutes 90 %. Measures are needed to enhance soil organic matter content and system recovery of organic substances.
3.	BH < 0 H =3-4 % GCN ≥ 70% GCP ≥ 90 % GCK ≥ 70% K_2O = 15- 20 mg/100g P_2O_5 = 3-2.5 mg/100g	Nm – low CSC =20-25 me/100g pH – basic Ca:Mg 6-8:1 Na me/100 g < 1 SA < 0.3 %	AAV=50-60 % DA = 1.3-1.4 g/cm^3 Ɛt = 40-50 % Ɛair > 30 % Ɛagr < 20 % Kstr = 1.0-0.7 AHS =40-50 %	Compliance degree of anthropogenic pressures and landscape capacity constitutes 70 %. Measures are needed to enhance soil organic matter content and optimization of physics parameters.
4.	BH < 0 H =2-3 % GCN ≥ 70% GCP ≥ 80 % GCN ≥ 70% K_2O < 15 mg/100g P_2O_5<2 mg/100g	Nm – low CSC < 20 me pH ≥ 8,2 Ca:Mg =6:1 Na me/100 g < 1 SA < 0.3 %	AAV=30-40 % DA > 1.4-1.6 g/cm^3 Ɛt < 40 % Ɛair < 40 % Ɛagr < 20 % Kstr < 0.7 AHS =30-40 %	Evolutionary trend carries degradative character. Crop rotations are mandatory measure to ensure stability of agrolandscape.

BH – balance of humus, H – humus content in arable layer, %, GCN, GCP, GCK – compensation degree of nitrogen content (N), phosphorus content (P), potassium (K) in soil, K_2O – exchangeable potassium content in soil, mg/100 g soil, P_2O_5, - phosphorus content mg/100 g soil, CSC – cation exchange capacity, mg/100 g soil, Ca:Mg – ratio of the cations Ca and Mg in soil adsorbtive complex, pH – soil reaction, Na – sodium content in the soil adsorbtiv complex, me/100 g soil, SA – salt content slightly soluble, %; AAV – valuable agronomic aggregate content (0,25-10,0 mm), %, DA – bulk density, g/cm^3, Ɛt – total porosity, %; Ɛair – aeration porosity, %; Ɛagr – aggregate porosity, %; Kst – structuring coefficient; AHS – hydrostable aggregate content, %, Nm – mineralized nitrogen

Based on the above we find that practically all arable soils require improvement measures for their physic features and functionality in relation to environmental components through adaptation of adaptive-landscape-ameliorative technologies.

The concept involves two basic categories: adaptation potential for landscape and adaptive capacity of plants. The adaptation potential for landscape is the expression of relation soil ↔ environmental components materialized in fertility factors, chemical, physic-chemical, agrochemical and biological.

Adaptive capacity of crops involves their ability to model adaptation potential of landscape in accordance with their potential. In this regard adaptive-landscape-ameliorative agricultural technologies involve the identification of technological elements and crops capable not only to ensure yields in quantities and required quality but also ensure improvement relation of soil with environmental components under which is provided enlarged reproduction of bioproductive soil function.

Through this prism of ideas adaptive-landscape-ameliorative agricultural systems include:

- Complex evaluation of soil fertility factors, relief conditions, geological structure and microclimate for each fields separately. Identification of priorities and risk factors, and technological elements respectively.
- Selecting crops and their location in specific landscape condition.
- Differentiation of crop rotation in accordance with their ability to provide improvement of adaptive potential of landscape (Table 6).
- Crop rotation with minimal cultures (5) will be admitted only when the stability degree of agrolandscape constitutes more than 90% and that pressure from outside correspond to fully capacity of self-reproduction and self-regulation of landscape. In the second and third group agrolandscapes, number of crops included in the rotation will increase as the degree of stability is reduced below 70% of ameliorative crop rotations.
- Promotion of leguminous plants within all crop rotations recommended for specific landscape conditions
- Using the most suitable technologies economically and environmentally, introduction of criteria pedo and ecoefficiency in all agricultural activities
- Limiting to a minimum degradation processes. Emphases will be placed primarily on the exclusion of physical processes and erosion.

CONCLUSIONS

Sustainable management of soil resources under evolutionary trend, natural and anthropogenic conditions involves the need for a new paradigm of integrated processes and their management. Within this emphasis following to be placed on restoring equilibrium between agrolandscape components responsible for enlarged reproduction of soil as the basis of landscape. Achieving this objective involves promoting and implementing adaptive-landscape-ameliorative technologies.

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