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Original Article

Researches Concerning some Elements of Agroecological Monitoring in Codrilor Plateau from Republic of Moldova

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Abstract

Several elements of agroecological monitoring have been investigated as component parts, and also subsystems of the integrated ecological monitoring, the first aiming to survey and control the agroecosystems in order to determine formation of highly effective agrocoenoses, ecologically balanced, able to harmoniously work with the agricultural environment, biotic and abiotic factors. Surveillance of the physical-mechanical indices in time and space in various ecosystems, including ecosystems without agricultural impact is an important and necessary component in controlling the overall condition of soil, in maintaining the productive capacity of lands on long term, in distinguishing changes in case of land degradation and application of regulation measures directed to the sustainable development of soils. Research of gray mollisols (greyzems, faeziom) and cambic chernozems belonging to the Central Moldavian Plateau has been complexly performed, by monitoring three groups of indicators - the diagnosis, seasonal changes (short-term) and long-term changes. Along with research of the physico-chemical properties of soil, the study of the physical-mechanical properties (plasticity, adhesion) has been realised in key polygons, included in the database monitoring network of soil quality. Were investigated soils of different textures within several agroecosystems - field crops in crop rotation, ecosystems as fruit growing, vegetables, fallow, as compared with natural ecosystems (forest), which can provide data for background monitoring. Research has shown that the clay-sandy varieties of the mollic gray soils recorded sensitive values passing from the lower to the higher limit of plasticity. The light varieties of soils are more affected by the processes of aridity degradation as compared to the clay loam varieties. Anthropogenic influence by tillage significantly alters the plasticity and adherence. In the mollic gray soil of the fruit growing ecosystem, the physical-mechanical indicators have worsened as a result of cleaning works and of surface work necessary for plantation maintenance. Soil adherence can be used as diagnostic parameter in assessing the level of human impact within agroecosystems. Highlighting the value of optimal humidity for soil tillage based on plasticity and adherence can provide methods for mitigation of land degradation, and measures for work, and subsequently - energy saving.

Keywords: monitoring, agroecosystems, gray mollisol, leached chernozem, plasticity, adherence.

1. Introduction

Agroecological monitoring is a subsystem of the integrated ecological monitoring, established to survey and control the state of agroecosystems, to provide highly effective agrocoenoses, ecologically balanced, which harmoniously works with all parts of the agricultural environment, biotic and abiotic factors.

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Among other objectives, functions and organizational principles agroecological monitoring is characterised by complexity, which includes supervision of three groups of indicators pointing and tracking dynamic changes and possible variability of agroecosystems. These are diagnosis indices, which can rapidly provide information about the status of certain components - soil, water, air, which significantly influences the productivity of agroecosystems, as well the optimal indices, which determine the balance of the component parts of agroecosystem, and the limiting parameters of its productivity.

Control of soil indicators within agroecological monitoring can provide information about short-term, seasonal and long-term changes which usually radically changes the value of soil and the ecological functions of biosphere.

Survey of soil within agroecological monitoring is necessary, and control of the physical-mechanical parameters provides information on the dispersion phase of soil, structural and microstructural degradation, chemical composition, content of organic matter, and more. The physical - mechanical parameters monitored in time and space are useful information sources in founding agroecological monitoring of impact, required components of the sustainable agriculture, allow detection of critical values showing the influence of anthropogenic impact on soil, and by appropriate interpretation of values concerning the physical-mechanical indices could be avoided the soil compaction, degradation of aeration, hydrological, nutritive regimes, degradation of pedofauna and biodiversity habitat, could be saved energy.

To assess changes of soil within agroecosystems and for its sustainable agricultural use, there are necessary comparative researches of the natural and anthropic ecosystems.

2. Materials and Methods

There were investigated several types of ecosystems and agroecosystems, with field crops, fruit-growing, vegetables, and for comparison there were included forest ecosystems. The evaluation included monitoring of complex physical-mechanical indices in a long time, concomitantly with full detailed research of soil, including the physical-mechanical parameters in different agroecosystems.

There were investigated and monitored the physical-mechanical properties of the following soils: clayey-sandy mollic gray soil from a forest ecosystem (forest – *Quercus robur, Tillia cordata* and herbaceous cover) and agroecosystem (plowing), profiles 44 and 42, described by Academician Andrei Ursu [5]; clay-loam mollic gray soil (Ivancea, county Orhei) in forestry coenosis, monitoring polygon no. 9 [3]; virgin gray soils (greyzems). The gray soil of agroecosystems is located within monitoring polygons 7 and 8 of Republic of Moldova network. As well, there were investigated leached (cambic) chernozems from Central Moldavian Plateau, adjacent to polygon no. 9.

The detailed characteristic of these soils considering the physical-chemical indices, granular and microaggregative composition [4], physical and hydrological features, compaction degree, structure and others, are presented in the works of synthesis of Moldavian Soils [3, 5].

Research methods are those recommended and used within the pedological monitoring of Republic of Moldova [2]. Plasticity and plasticity index have been determined according to method of A. Vasiliev. Soil adherence (kPa) has been determined according to the method of N. Kacinski on metal surfaces by 10 cm^2, disk pressure - 0.005 MPa, 30 seconds lasting, 10 repetitions. For assessment, the comparative analysis of data from several agroecosystems was used.

3. Results and Discussion

Cambic chernozems and gray mollic soils in the central area of Moldova, forests of Codri, occupy the largest areas, respectively 48200 ha (97%) and 26500 ha (5.3%), being widely used in agriculture.

Mollic gray soils, due to the podzolic process and humus accumulation, are characterised by differentiation eluvial - illuvial on profile, less pronounced as textural level, as compared with typical and gray luvisols. These have been constituted in watersheds and on versants with altitude by 236-342 m.

Results of the physicochemical research of gray mollic soils (agroecosystems, Durleşti locality) are presented in table 1. Comparative characteristics of soils from anthropic ecosystems and forest ecosystem are listed in table 2 and table 3.

Data shows that humus content at soil surface varies between 3.28 to 1.92%, carbonates are deeply leached, pH values range from neutral values, low acidic to low and moderate alkaline (table 1, 2, 3).

Hydrolytic acidity of soil reaches 3 to 4.3 me/100g. The soils are different as textural varieties from clay-loam (profile no. 9) to sandy-loam (table 2), and considering the humus content of soil these have moderate and low content, the degree of base saturation (%) is 85% in the surface horizons, the sum of exchangeable bases in soil ranges from 31 to 32.6 me/100 g soil in the gray mollic soil of the forest ecosystem and from 21 to 37.8 me/100 g soil in the gray mollic soils of agroecosystem.

The research concerning plasticity of clayey-loamy soils of the forest ecosystem and agroecosystems (Durlesti, 2010) is presented in table 4. The superior plasticity of soil within the forest ecosystem ranges in A-AE and B_1 horizons from 40.7 to 19-21%, values influenced by genesis of gray soils, and the limit of inferior plasticity tend to be close to the superior plasticity, unnoticed phenomenon in the clay-loam gray soils, but also distinguished in brown soils with light texture.

Table 1. Physico-chemical characteristics of gray mollic soils, Durlesti locality, 2010

Soil	Depth, cm	Hygroscopic water, %	Humus, %	Carbonates, %	pH		Hydrolytic acidity, me/100 g soil	Particle size (mm, %)	
					aqueous	saline		>0.01	<0.01
Loam gray mollic	0-10	4.49	2.81			5.9	3.2	57.67	42.33
	30-40	4.38	1.97				3.9		
	50-60	4.60	1.78			5.3		51.58	43.42
	70-80	4.27	1.09						
	90-100	4.49	075						
	110-120	4.60	0.59	2.6	7.8			51.38	48.62
Clay loam gray mollic	0-10	4.38	2.84			5.4	4.4	52.86	47.14
	30-40	4.60	1.90				2.9		
	50-60	4.71	1.56			5.5			
	70-80	4.38	0.90					54.06	45.94
	90-100	4.27	0.75						
	100-110	4.38	0.50	2.2	7.8			57.20	42.80
Loam gray mollic	0-10	4.38	3.28			4.8		56.54	43.46
	30-40	4.60	2.50						
	50-60	4.38	1.62						
	70-80	4.71	1.09			4.7		52.24	47.76
	100-110	4.49	0.62						
	110-120	4.16	0.59	9.4					
	120-130	4.05	0.31	9.6	8.6			47.13	52.87
Loam gray mollic	0-20	3.84	1.92			5.1	3.6	62.92	37.08
	30-40	3.41	1.85				4.3		
	50-60	3.51	1.14			5.2		68.18	31.82
	70-80	3.50	0.71						
	120-130	3.09	0.34	8.0	8.7			75.72	24.28

Table 2. Physico-chemical characteristics of loam-sandy soil gray mollic (arable), Profile 42 [5]

Depth, cm	Hygroscopic water, %	Humus, %	Exchange cations, me/100 g sol			Hydrolytic acidity, me/100g sol	Degree of saturation with bases, %
			Ca^{2+}	Mg^{2+}	total		
0-10	1.23	2.02	19.23	1.83	21.06	3.5	85.6
15-25	1.10	1.28	19.01	1.61	20.62	4.4	82.3
35-45	0.60	0.64	16.10	1.61	17.71	4.2	80.9
55-65	3.36	0.55	24.39	7.44	31.83	2.2	93.4
80-90	3.92	0.56	27.85	9.98	37.83		

Table 3. Physico-chemical characteristics of loam-sandy soil gray mollic (arable), Profile 44 [5]

Genetic horizon	Depth, cm	Hygroscopic water, %	Humus, %	pH	Exchange cations, me/100 g soil			Hydrolytic acidity, me/100g soil	Degree of saturation with bases, %
					Ca^{2+}	Mg^{2+}	total		
A_1	0-7	2.64	3.87	5.87	26.28	4.92	31.20	5.39	85.27
AE	10-20	1.0	1.49	3.95	16.16	2.02	18.18		
AE	30-40	1.03	0.43	4.40	16.97	2.83	19.80	4.42	81.75
B_1	50-60	2.88	0.42	4.35	23.05	5.76	28.81	4.95	85.34
B_2	70-80	3.69	0.30	4.57	24.47	8.09	32.56	4.54	87.76
B_3	90-100	3.00		6.65					
C	140-150	3.81		7.80					

The gray soils of agrocoenoses recorded low values of superior and inferior plasticity, which indicates significant changes in the dispersion phase of the soil as a result of agricultural use. The upper horizons of the gray mollic soil of agroecosystems are characterized by heterogeneity both considering the superior and inferior limit of plasticity, the plasticity index is low, only 2-4%, and shows values indicating transition from superior limit to inferior limit, properties which involve water loss with soil tillage, structure alteration by traffic with agricultural machines, inadequate conditions of seedbed in the sowing/planting processes, and more.

Data regarding adherence of the gray mollic soil from the forest and anthropic ecosystems (table 5) (locality Durlesti) shows very low and low adherence in the forest ecosystem, in the surface horizon (0-20 cm).

Table 4. Plasticity of gray mollic soils in different ecosystems in Durlesti locality, 2010

Depth, cm	Limits of plasticity, %		Plasticity index, %
	Superior	Inferior	
Agrocoenoses (arable land), profile 42			
0-10	19.8	17.9	1.9
10-20	18.8	17.8	1.0
20-30	20.4	16.5	3.9
35-45	14.4	13.7	0.7
55-65	26.8	20.0	6.8
70-80	30.4	21.5	8.9
Forest coenosis (forest), profile 44			
0-7	40.7	36.6	4.1
10-20	24.7	23.0	1.7
30-40	19.0	16.7	2.3
40-50	20.8	16.8	4.0
55-65	28.3	23.0	5.3

Table 5. Comparative relationship between adherence (g/cm^2) and humidity (%) of gray mollic soils, Durlesti, 2010

Depth, cm	Indices	Humidity and adherence						
Forest ecosystem								
0-7	Humidity,W, %	32.2	39.9	40.1	41.1	44.7	51.8	61.9
	Adherence, g/cm^2	0.3				0.3	1.1	0.2
10-20	Humidity,W, %	22.1	22.1	23.0	23.8	27.7	32.8	35.6
	Adherence, g/cm^2					1.1	0.1	0.6
30-40	Humidity,W, %	17.1	17.4	18.2	19.4	20.6	21.5	36.4
	Adherence, g/cm^2		1.3	4.0	1.9	0.9	2.4	6.1
40-50	Humidity,W, %	16.3	19.8	20.3	22.5	25.5		-
	Adherence, g/cm^2					6.3		-
55-65	Humidity,W, %	17.3	21.3	21.9	22.0	26.8	32.5	33.8
	Adherence, g/cm^2							0.8
70-80	Humidity,W, %	14.2	20.5	20.9	24.9	29.8		
	Adherence, g/cm^2		6.4	3.9	7.1	4.3		
Anthropic ecosystem								
0-10	Humidity,W, %	14.0	15.7	15.7	18.9	22.1	24.0	
	Adherence, g/cm^2				2.7	5.7	2.8	
10-20	Humidity,W, %	17.0	18.4	18.5	19.6	19.9	20.2	
	Adherence, g/cm^2		3.9	1.3	4.5	4.8	9.7	
20-30	Humidity,W, %	13.9	14.2	14.3	15.4	24.7		
	Adherence, g/cm^2				0.4	3.5		
35-45	Humidity,W, %	13.5	14.1	14.2	14.9	16.2	17.1	40.2
	Adherence, g/cm^2					5.9	5.6	4.1
55-65	Humidity,W, %	16.7	17.7	19.5	19.7	21.5	22.6	30.2
	Adherence, g/cm^2			0.4	0.6	9.7	5.5	3.5
70-80	Humidity,W, %	18.3	20.4	21.5	24.1	27.4	29.3	
	Adherence, g/cm^2		4.7	5.0	6.1	7.2	7.0	

Within the anthropic ecosystem, the loss of humus, soil structure, and others, significantly increased the adherence up to 4-5 g/cm^2 and even to 10 g/cm^2, 10 times higher than the forest ecosystem. It is obvious that degradation processes determined by humus loss and structure alteration influence the physical-mechanical indices, and the energetic cost required by tillage will considerably increase. The works in condition of optimal humidity lead to degradation by water loss, and works in excess of humidity will lead to compaction of the arable and sub-arable layers, together with all consequences of agrochemical degradations, expressed in terms of aeration, nutritive, biological regimes, and others. Simultaneously, there were researched the physical-mechanical properties of gray soils of the locality Ivancea, Orhei county, in polygons included in the database of the ecological monitoring network [2]. The limits of plasticity characterising the genetic layers of the gray mollic soil, Ivancea, 1985, are shown in table 6, and the comparative data regarding the plasticity values of this soil in different agroecosystems, Ivancea, 2010, is presented in table 7.

Table 6. Plasticity of the gray mollic soil, Ivancea, 1985

Genetic horizons	Depth, cm	Limits of plasticity, %						Plasticity index,%
		Superior			Inferior			
		M	±m	V	M	±m	V	
A	0-10	36.2	0.35	1.67	23.0	0.55	4.15	13.2
AE	30-40	37.9	0.42	1.91	22.0	0.62	4.87	15.9
B_1	50-60	42.7	0.18	0.72	24.0	0.45	3.25	18.7
B_2	70-80	42.3	0.19	0.76	22.4	0.49	3.79	19.9
BC	90-100	43.4	0.29	1.16	22.3	0.36	2.80	211
C	140-150	37.6	0.58	2.66	19.4	0.55	4.86	18.2

Table 7. Plasticity values of soils from different ecosystems, Ivancea locality, Orhei county, 2010

Depth, cm	Limits of plasticity, %							
	Superior				Inferior			
	Gray mollic soil			Leached chernozem (vegetables)	Gray mollic soil			Leached chernozem (vegetables)
	Forest coenosis	Agroecos ystem	Orchard		Forest coenosis	Agroecos ystem	Orchard	
0-10	54.4	39.2	40.7	39.8	39.5	23.8	20.8	23.2
10-20	44.8	39.4	38.7	41.1	30.3	22.4	23.3	22.1
20-30	38.3	40.6	37.4	41.4	22.1	23.3	21.1	22.2
30-40	37.3	42.7	37.6	42.3	25.1	25.1	23.1	22.0
40-50	40.7	45.0	43.9	44.9	24.5	26.5	26.0	22.8
50-60	43.9	41.3	42.7	44.8	23.7	23.7	22.6	23.0
60-70	42.4	41.2	42.7	43.0	22.9	22.5	20.7	23.8
70-80	45.1	42.9		43.0	25.0	21.6		20.4
80-90	40.7	40.3		43.2	23.2	22.9		22.5
90-100	39.6	38.0			22.1	29.2		

Table 8. Relationship between adherence (Ad, g/cm^2) and humidity (W,%) of the arable and sub-arable horizons in different ecosystems, values close to the limits of plasticity, 2010

Depth, cm		Limits of plasticity, %							
		Superior				Inferior			
		Gray mollic soil			Leached chernozem (vegetables)	Gray mollic soil			Leached chernozem (vegetables)
		Forest coenosis	Agroecos ystem	Orchard		Forest coenosis	Agroecos ystem	Orchar d	
0-10	W	46.5	36.1	32.6	34.6	37.0	23.2	22.6	24.8
	Ad	0.8	4.6	1.9	2.3		0.9	2.2	2.2
10-20	W	43.6	35.0	34.5	41.6	30.1	23.2	24.7	22.0
	Ad	1.9	3.6	2.8	2.0	1.4	2.6	2.4	1.5
20-30	W	37.6	35.0		43.6	22.4	23.7		24.4
	Ad	1.5	3.6		1.8	2.0	3.5		2.0
30-40	W	31.3	42.7	30.0	43.2	25.0	24.7	23.0	23.1
	Ad	2.3	2.7	3.3	2.9	2.3	3.4	1.8	2.3
40-50	W	47.1	32.0	48.0	33.7	24.5	26.8	25.0	21.5
	Ad	2.5	2.6	2.7	2.4	2.3	4.2	1.4	2.3

For the gray mollic clay - loam soil, the superior limit of plasticity is 37-38%, and the inferior limit of plasticity is 22-23% in arable and sub-arable horizons. The clay-loam varieties are characterized by plasticity index of 13-15%, and thus a more advantageous possibility of choices in land tillage as compared with light varieties, which if not worked, they lose the available water.

The adherence of the arable horizons of soil at the inferior limit of plasticity is 3.2 g/cm^2 (0.2 to 0.3 kPa), therefore it is recommended to work this type of soil at moisture level by 19-20%, when fuel costs will be lower, as compared with soil moisture over 23%. Indices close by the inferior limit of plasticity were also recorded in the arable horizons of the leached clay-loam chernozem, located adjacently to the clay-loam gray soils. Research of plasticity and adherence of gray soils conducted in different agroecosystems, including forest coenosis (2010) are shown in tables 7 and 8. Results show that the highest values of the superior and inferior plasticity have been recorded in the forest ecosystem (30-

39%) on soil surface. Within 25 years, the inferior plasticity remained unchanged, unlike the values of adherence which varied toward worsening of tillage conditions and increase of tillage energy, considering that adherence occurs at lower values of humidity, and for humidity corresponding to the inferior limit of plasticity (abandoned orchard) the adherence of soil is 2.2 g/cm^2. These regularities are also recorded for the leached chernozem adjacently located (table 8).

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Table 9. Humidity (W, %) of the arable and sub-arable horizons with maximal values of adherence (Ad, g/cm^2) and without adherence (year 2010)

Depth, cm		Limits of plasticity, %							
		Maximal values				Without adherence			
		Gray mollic soil			Leached chernozem (vegetables)	Gray mollic soil			Leached chernozem (vegetables)
		Forest coenosis	Agroecos ystem	Orchard		Forest coenosis	Agroecos ystem	Orchard	
0-10	W	46.5	58.4	32.6	30.7	42.6	16.1	19.7	18.2
	Ad	0.8	5.3	1.9	3.1				
10-20	W	49.1	32.5	30.5	41.6	24.6	16.4	18.9	19.4
	Ad	1.5	3.0	2.7	2.0				
20-30	W	37.6	35.0		43.6	18.6	13.1		20.5
	Ad	1.5	3.6		1.8				
30-40	W	30.5	42.7	25.7	43.2	18.0	21.0	19.8	19.8
	Ad	2.3	2.7	3.23	2.9				
40-50	W	47.1	33.3	48.0	33.7	15.5	20.0	15.3	16.6
	Ad	2.5	2.7	2.7	2.4				

Determination of adherence of soil samples in natural arrangement for wide ranges of humidity, usually between superior limit of plasticity and even more than that and the lower limit of plasticity, to that value of humidity where adherence is missing, allowed the highlighting of the maximal adherence and humidity level of soil. In table 9 are shown values of humidity in soil without adherence.

4. Conclusions

Physical-mechanical indices of soil can be used in the agroecological monitoring because these are ecopedological parameters diagnosing the level of anthropic impact and these allow the application of technological measures in the sustainable management of agricultural lands.

Plasticity of the gray mollic soils of the agroecosystems has significantly changed under the influence of soil tillage as compared with natural ecosystems in which they were formed.

Light textured soils are more susceptible to technology works.

Anthropic ecosystems supported degradation not only as general physical overview, chemical, physical-chemical, but also physical-mechanical.

Adherence of the surface horizons of soils increased 4-5 times in agroecosystems as compared with background ecosystems.

Among all researched agroecosystems, strongly degraded under physical-mechanical aspect was the agroecosystem of field crops with gray mollic soil.

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