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AGRICULTURAL CHEMICAL EVOLUTION OF BLACK SOIL

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The study of changes in agrochemical properties of ordinary hard loamy black soils under the influence of anthropogenic factors prolonget action. For this purpose, a comparative assessment of two soil profiles in arable land and virgin soil was conducted. In the arable land was seen the agrochemical properties deterioration, especially in the upper layers.

Keyword: *soil, fertilizer, degradation, fertility.*

For the purpose of studying of changes which have occurred in ordinary chernozems during their long-term usage in an agricultural production at the conditions of the droughty climate of Steppe zone of Ukraine, to give a comparative estimation of agrochemical and agrophysical indi-cators of these soils on a virgin soil and on an arable land, by means of all-round estimation of their soil profiles with depth of two meters.

The purpose of these researches consists in creation of preconditions for stoppage of negative processes which occur in chernozem soils of Steppe zone of Ukraine. First of all it concerns for stoppage of dehumification, erosive phenomena, depletion of soils with nutritious elements, de-toxication of soils polluted by heavy metals, creation of favorable conditions for growth and deve-lopment of plants in droughty conditions of Steppe zone of Ukraine and to develop the measures for increase of their adaptation to a drought.

For stoppage of dehumification it is necessary to carry out researches on reconstruction of crop rotations in a direction of increase in a share of cultures of continuous row sowing and perennial grasses; usage of aftermatch residues and straw of grain crops as organic fertilizers, appli-cation of sapropel, green manuring, pond ooze and others carboniferous materials. To carry out re-searches for the purpose of increase of crop return and liquidation of existing deficiency in soil of availability forms of nutrients. For the purpose of development prevention of degradation processes in the soils polluted by heavy metals, it is necessary to develop technological measures on soils detoxication.

Researches were conducted in 15 stationary and 46 interim field experiences of laboratory of soils fertility of State institution Institute of Agriculture of Steppe Zone of National Academy of Agrarian Sciences of Ukraine in the course of 30 years from 1984 till 2014. As the soil covering of experimental plots was ordinary chernozem heavy clayey loam low in humus on loess. The depth of humus profile – 60–65 cm, total content of humus (on Tyurin) in an arable layer makes – (3,8–4,0 %), the general nitrogen – 0,23–0,24 %, phosphorus – 0,10–0,12 %, potassium – 2,1–2,5 %. Quantity of availability forms of phosphorus – 8,8–9,8 mg/100 g soil, availability potassium – 14,3–15,4 mg/100 g soil (F. V. Chirikov's method), nitrates – 13,5–15,4 mg/100 g soil (spectrophoto-metric method).

The total content of microelements was such: Zn – 38,8–40,4; Mn – 473,0–484,0; Cu – 12,5–14,2; Co – 8,0-8,3; Fe – 835–845; Pb – 32,4–33,0; Cd – 0,38–0,39 mg/kg and according to their availability forms which represent small percent from the total content: available Zn – 0,96–1,2; Cu – 0,13–0,15; Co – 0,42–0,48; Mn – 57,5–63,8; Fe – 27,6–27,8; Pb – 0,05–0,10; Cd – 0,10–0,11 mg/kg soil. Reaction of soil solution was neutral, pH_{water} = 6,6–7,0. The field moisture capacity in the layer of soil 0–10 cm makes 31,8, and in 10–20 cm – 29,0 % from weight of soil. The water regime in the given region concerns not washing type.

We used in experiences the standardized methods of research conducting. All analytical researches carried out in triple analytical replication. At conducting of researches was established the cooperation with National Science Centre Institute of Soil Science and Agrochemistry named after O. N. Sokolovskyi of National Academy of Agrarian Sciences of Ukraine, National Science Centre Institute of Agriculture of National Academy of Agrarian Sciences of Ukraine, Institute

of Physiology of Plants and Genetics of National Academy of Agrarian Sciences of Ukraine, State institution «Institute of Soils Conservation», State institution Institute of Agroecology and Nature Management of National Academy of Agrarian Sciences of Ukraine, All-Russia Scientific Research Institute of Agrochemistry named after D. M. Pryanishnikov of the Russian Academy of Sciences, the Dnipropetrovsk National University named after Oles` Honchar.

In Ukraine 70 % of territory represent agricultural lands, from them the arable lands occupies almost 33 million hectares or 80 %. Development of land fund is kept at level about 60 % against 12 % in the USA. Under an arable lands there are 57,3 % of total area, or 79,5 % of agricultural lands. Counting on soul of the population their area makes 0,83 hectares, and the arable land area – about 0,66 hectares. It testifies that the soil covering in Ukraine is exploited very intensively [1].

It is necessary to consider that 10,2 million hectares of arable lands are destroyed by water, and 5,0 million hectares – by wind erosion. The area of erosion-dangerous soils has already reached point of 17 million hectares and continues to increase. In structure of erosive soils 4,5 million hectares are medium – and strongly washed off, including 68 thousand those hectares that have completely lost humus horizon. Strengthening of erosion processes and deflation of soil covering have caused necessity of development more effective modern methods of soils conservation from erosion [2, 3].

In accordance with materials of large-scale researches in the course of 1957–1961 years in Ukraine distinguish over 800 kinds of soils. Among them chernozem soils occupy the leading position, which occupy about 60 % of the Ukrainian arable lands. These soils differ with super deep of humus layer, perfectly expressed granular structure, in almost ideal density of soil structure, a good and moderate stock of nutrients. The chernozems are the fertile soils of the world, but also they have started to degrade recently strongly. Their usage was conducted earlier and conducted nowadays with full ignoring of the law of nutrients returning in soil. Long conducting managing by the extensive has by led to an unstable condition of area of agriculture. On this background volumes of application of organic and mineral fertilizers have sharply decreased. For today we have sharply negative balance on all their indicators. And it is one of the reasons of that soil covering in cultivation degrades.

Dominant cause is low level of application of mineral and organic fertilizers. Since 1970 and till 1990 in Ukraine widely used fertilizers. Then on the arable lands introduced 6–9 t/hectare of organic fertilizers, 60 kg/hectare of active substances nitrogenous, and 30–40 kg/hectares of phosphorous and potassium fertilizers. The application of organic fertilizers for last 19 years (1995–2014) has decreased to 2–3 t/hectare, and mineral fertilizes – according to 16–20 kg/hectare of nit-rogen, 3–4 kg/hectare P_2O_5 and 1,8–2,2 kg/hectare K_2O at optimum requirement of organic fer-tilizes 8 t/hectare and mineral fertilizers 180–200 kg/hectares of active substance. All of this has automa-tically caused decrease in the basic agrochemical indicators of soil fertility. Last years annual hu-mus losses make in the Steppe zone – 0,5–0,6 t/hectare. Nowadays soil resources are considered in the society basically as the source and means of making a profit, not accenting thus attention that without care of soil conservation, preservation and reproduction of soil fertility their natural value is lost. Unfortunately, highly fertile chernozem has remained only in virgin conditions.

Agrochemical changes which have occurred in ordinary chernozems are accurately visible from the data resulted in (table 1) with which help the comparative estimation of ordinary chernozems on the virgin soils and an arable lands is made.

It has appeared, that the best in the world chernozems are very sensitive to anthropogenous intervention and under the influence of excessive loading are capable to turn in the ploughed degraded ground.

On such soil it is heavy to realize the genetic potential of productivity of modern varieties and hybrids of agricultural crops and it is almost impossible to create favorable conditions for growth and development of agricultural plants during their vegetation.

It is necessary to establish, that degradation is quite a challenge. Only introduction of

agrotechnical measures here not to manage. Degradation is evident in destructurization, repacking, salinization, pollution, depletion by nutrients and other negative processes which considerably worsen agronomical value of soils and their efficiency. For some time past the volume of works on increase of fertility of soils have decreased to the minimum sizes.

1. Reaction of soil solution and humus content and availability forms of phosphorus and potassium in ordinary chernozems of steppe zone of Ukraine on the virgin soil and on ploughed field (an average for 2010–2011 years)

Layers of soil, cm	Ploughed field				Virgin soil			
	pH_{water}	humus, %	Content in mg/kg soil		pH_{water}	humus, %	Content in mg/kg soil	
			P_2O_5	K_2O			P_2O_5	K_2O
1	2	3	4	5	6	7	8	9
0–5	7,2	4,20	167	237	7,0	8,	163	795
6–10	6,8	4,10	167	181	6,5	6,76	112	469
11–15	6,6	4,06	169	133	6,5	5,48	92	393
16–20	6,6	3,81	168	130	6,5	5,47	96	312
21–25	6,6	3,80	172	103	6,8	4,99	88	181
26–30	6,5	3,81	164	92	7,0	4,20	83	129
31–40	6,9	3,20	112	100	7,3	3,69	78	104
41–45	7,2	2,83	92	96	7,3	3,32	77	102
46–50	7,3	2,72	94	96	7,4	3,20	75	103
51–55	7,6	2,35	107	53	7,8	2,95	64	104
56–60	8,2	2,23	54	99	7,8	2,72	79	98
61–65	8,3	1,97	53	95	7,9	2,47	88	95
66–70	8,3	1,45	59	94	8,1	1,70	53	92
71–75	8,3	1,31	53	94	8,2	1,83	58	93
76–80	8,4	1,18	62	85	8,3	1,45	39	95
81–85	8,4	1,06	56	91	8,3	1,31	41	79
86–90	8,4	0,95	54	89	8,3	1,31	36	78
91–95	8,4	0,83	50	89	8,3	1,31	35	76
96–100	8,4	0,60	51	96	8,3	1,06	34	76
101–105	8,4	0,55	50	91	8,4	1,00	34	75
106–110	8,4	0,55	50	90	8,4	1,00	35	74
111–115	8,4	0,50	50	94	8,4	1,03	38	82
116–120	8,5	0,50	48	91	8,4	0,28	38	82
121–125	8,5	0,50	48	93	8,4	0,25	39	82
126–130	8,5	0,5	48	93	8,4	0,25	39	82
131–140	8,5	0,35	51	94	8,4	0,10	40	86
141–145	8,5	0,35	52	93	8,4	0,10	40	90
146–150	8,5	0,35	49	98	8,4	0,10	41	94
151–155	8,6	0–35	50	62	8,4	0,10	40	86
156–160	8,6	0,35	53	76	8,4	0,10	40	86
161–165	8,5	0,35	57	98	8,4	0,10	40	88
166–170	8,5	0,30	62	97	8,4	0,10	42	92
171–175	8,5	0,30	73	89	8,4	0,10	42	88
176–180	8,5	0,30	77	95	8,4	0,10	44	94
181–185	8,6	0,30	69	100	8,3	0,10	45	93
186–190	8,5	0,30	73	100	8,4	0,10	48	89
191–195	8,5	0,30	74	103	8,4	0,10	52	90
196–200	8,5	0,30	78	99	8,4	0,10	55	93

At the same time with agrochemical degradation, there is an agrophysical degradation which is caused by negative influence of agricultural machinery on soils. It is shown in deterioration of their physical properties, water-, air-, and heat and nutrient regimes. Growth of quantity of soil aggregates in the size > 0,25 mm in the top layer of soil 0–10 cm indicates on diffusion of soil in comparison with the bottom layer (table 2).

At the same time it is observed also technogenic pollution of soils with different pollutants among which the leading position is occupied with heavy metals. So, in radius to 15 km round the industrial enterprises the soils are polluted by heavy metals, and on the considerable territory of our country soil contains the raised quantity of radioactive nuclides. In this connection on the given soils it is urgently necessary to solve questions not only increase of their fertility, but also carrying out on the polluted soils detoxication with different toxic substances.

2. Structural composition of ordinary chernozems on an arable land, dry calcination (an average for 2001–2013 yeras)

Layers of soil, cm	Structural fractions фракции (mm), %								
	>10	10	>7	>5	>3	>2	>1	>0,5	>0,25
0–10	0,7	1,1	4,1	11,4	10,5	49,5	2,4	7,7	12,6
11–20	10,2	13,8	15,3	17,8	8,8	24,8	1,2	3,4	4,7
21–30	18,6	16,2	15,9	16,9	7,9	17,0	0,8	2,2	4,5

For same time past agriculture of Ukraine suffers from action of natural cataclysm – droughts which are especially strongly shown in a steppe zone. The steppe zone divide on humidifying conditions on three subzone: Northern insufficiently humidified with hydrothermal coefficient 0,83–0,89, Northen-central moderately droughty with hydrothermal coefficient 0,76–0,82 and South central droughty with hydrothermal coefficient 0,68–0,75.

According to climatic conditions of aridization decreases the usefulness of territory for agriculture. In the zone of Southern Steppe climatic conditions worsen even more. The zone of dry step-pe which is most arid in Ukraine, on climatic features is divided on two parts: dry with hydrothermal coefficient 0,52–0,60 and very dry with hydrothermal coefficient 0,45–0,51. In these regions sharply raises the probability of droughts which negatively affects on growth and development of plants. Therefore productivity of the majority of cultures in nonirrigated conditions is low, except for a winter wheat after bare fallow. The stabilization of agricultural production in the given region is possible thanks to irrigating land improvements and expansion of crops of wheat after bare fallow.

Prospects. Considering gravity of situation which has formed nowadays, soils conservation, struggle against degradation and pollution can proceed successfully only at the state level. Inadmissibility of influence on soil, which can lead to deterioration of its quality, to degradation, pollution and destruction should be a key principle of the legislation. For preservation of natural fertility of soil and achievement of equilibrium balance of basic nutritive elements it is necessary to introduce every year on 1 hectares of an area under crops with different kinds of fertilizers not less than 70 kg nitrogenous, 25 kg phosphorous and 35 kg potassium fertilizes in active substances. That is the minimum requirement for nutrients makes 130 kg/hectare NPK in active substances.

Low availability of nutrients in chernozem is usually caused by specific climatic factors and first of all deficiency in it of a productive moisture. Therefore in this region it is necessary to direct the efforts of agriculturists to accumulation and preservation of moisture in soil. Low efficiency of potassium fertilizers on chernozems is connected not so much with satisfactory security of soils with potassium, as with the moisture lack.

In connection with high content of calcium carbonates and magnesium carbonates in ordinary chernozems, in these soils decreases the degree of microelements mobility. Therefore deficiency of available forms of microelements on these soils predetermines the application of microfertilizers in the chelating form, as obligatory agricultural method.

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