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ARTICLE

PROFILE RESEARCHES OF NATURAL AND AGROGENE CHERNOZEMIC SOILS BIOLOGICAL ACTIVITY IN THE BELT OF STEPPE MEADOWS OF CENTRAL CAUCASUS (KABARDINO-BALKAR REPUBLIC)

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ABSTRACT

The profile research and the morphogenetic description of various subtypes of the natural and agrogene mountain chernozemic soils widespread in a belt of steppe meadows of the Elbrus option of zonation of Kabardino-Balkaria is conducted. Parameters of biological activity are set: content and a reserves of humus, rate of basal and substrate - induced respiration, content and reserves of carbon of microbial biomass, enzyme activity oxidoreductases (catalase, dehydrogenase) and hydrolase (invertase, urease, phosphatase) in profiles of virgin and arable mountain chernozemic soils ordinary, typical and leached. It is shown that the changes of parameters of biological activity which resulted from arable use have difficult and ambiguous character. Steady distinctions at the level of subtype, both in virgin, and in arable mountain chernozemic soils are not revealed. The main changes of indicators of biological activity are observed in the arable horizons. To establish the general level of biological activity and to estimate the extent of its change, the uniform estimated criterion - the integre index of an ecological and biological state of the soil (IIEBSS) is applied. High level of profile biological activity of natural and arable mountain chernozemic soils is established, and differences in IIEBSS values between profiles of agrogene and natural soils are practically absent. The IIEBSS values defined for the top horizons (0-20 cm) indicate noticeable easing of biological activity (for 16-43%) in the arable horizons of all subtypes of mountain chernozemic soils.

KEY WORDS
mountain chernozemic soils, biological activity

INTRODUCTION

Mountain chernozemic soils - the unique, high-fertile soils occupying the space about 845 km2 (500-1200 m above sea level) in Kabardino-Balkar Republic and actively used under an arable land, long-term plantings, haymakings and pastures. At agricultural influence there is a continuous and intensive influence on the main modes and properties of soils. At the same time a necessary condition of their further arable use is maintaining fertility and creation of optimum conditions of growth of cultural plants (corn, sunflower, etc.). Though the main changes of soil properties happen in the arable and subarable horizons [1], it is necessary to track the direction of dynamics of biological activity in all a profile of the processed soils that was highlighted with leading experts in the field of biology of soils [2]. Biological properties of mountain chernozemic soils of Central Caucasus were not investigated earlier, but in a number of works [3-5] the efficiency of studying of various biological characteristics of soils when determining extent of negative anthropogenic impact is shown.

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Thus, a research objective is definition of extent of change of the general level of profile biological activity of various subtypes of arable mountain chernozemic soils in comparison with their virgin analogs in a belt of steppe meadows.

METHODS

The explored area is located at the height of 560-850 m above sea level (a.s.l.) in the territory of the Elbrus option of zonation which differs in rather arid and continental climate which is formed under the influence of free circulation of winds of Prikaspia [6]. Climatic conditions at which mountain chernozemic soils around researches function are characterized with the average annual air temperature of +7,80 C. The, rainfall has on average 560-700 mm/year, evaporability of 707 mm/year, duration of the no-frost period from March to November, the sum of average daily temperatures (more than +1000C) during active vegetation (174-177 days) makes about 30000 [7]. The hydrothermal mode of mountain chernozemic soils which is formed under such circumstances is favorable for activity of a soil biota and also cultivation of crops and long-term fruit plantings. Conditions of the Elbrus option contributed also to the development of dense natural grassy meadow and steppe vegetation on mountain chernozemic soils which quite often forms a dense organic mat at a protective covering of herbage about 100%.

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Mountain chernozemic soils lie on plateau-like heights where possess the full-developed profile. The leveled sites almost completely are opened, as well as mild slopes. Soilforming breeds are products of aeration of carbonate dense sedimentary breeds - eluvia-slide-rocks of limestones, sandstones, limestones and marlstone, carbonate clays and loams [8, 9]. Rubble and stony inclusions of carbonate maternal breeds quite often meet from a surface and on all profile of mountain chernozemic soils.

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Collecting and the analysis of soil samples for determination of physical and chemical and biological properties of natural and arable mountain chernozemic soils (ordinary, typical, leached) carried out by the standard methods in ecology and soil science [10]. Lying of cuts and sampling on the genetic horizons were made in the first decade of July, 2016 the soils not subject to slope erosive processes having characteristic morphogenetic properties and the full-developed profile were considered. Soil cuts were put in characteristic natural meadow biogeocenoses and in agrocenoses under crops of corn in a stage of formation of an ear [Table 1].

Table 1: The locations of cuts of mountain chernozemic soils in natural and agricultural biogeocenoses of the explored territories

Arable mountain chernozemic soils		Natural mountain chernozemic soils	
Name of the soil	Coordinates of the place of laying of a section	Name of the soil	Coordinates of the place of laying of a section
The chernozemic soil ordinary carbonate average thickness low-humus heavy loam on yellow-brown carbonate clays	Zolsky district, surrounding settlements of Kamennomostskoye, h-850 m a.s.l., 43º45'01 "N 43º1'34 "E	The chernozem is ordinary carbonate low-power average humus average loamy on yellow-brown carbonate loams	Zolsky district, surrounding settlements of Kamlyukovo, h-752 m a.s.l., 43º46'3 "N 43º12'41 "E
The chernozem typical average thickness low-humus heavy loam on yellow-brown carbonate clay breeds with pebble impurity	Baksan district, surrounding settlements Top Kurkuzhin, h-694 m a.s.l., 43º43'38 "N 43º21'16 "E	The chernozem is typical average thickness average humus average loamy on yellow-brown carbonate clay breeds with pebble impurity	Baksan district, surrounding settlements Top Kurkuzhin, h-856 m a.s.l., 43º41'39 "N 43º14'60 "E
The chernozem leached average thickness low-humus average loamy on brown carbonate loams with impurity of crushed stone and pebble	Baksan district, surrounding settlements Top Kurkuzhin, h-578 m a.s.l., 43º45'58 "N 43º22'46 "E	Leached chernozem average thickness low-humus average loamy on yellow-brown carbonate deposits of coarse-grained rough sand and crushed stone	Baksan district, surrounding settlements of Islamey, h-561 m a.s.l., 43º40'44 "N 43º26'42 "E

Besides, the method of "envelope" selected samples of various subtypes of the virgin and processed mountain chernozemic soils in a layer of 0-20 cm which reflect properties of the arable and humic and accumulative horizons of the explored soils, selection volume for each subtype was 16-18 samples. When determining places of sampling used the soil card and personal navigator GPS MAP 60 CEX [11]. Classification diagnostics of the studied subtypes of chernozemic soils was performed according to genetic classification of soils [12].

Lying of soil cuts and sampling of virgin mountain chernozemic soils were made within undisturbed natural meadow biogeocenoses. Geobotanical descriptions carried out on each site. Determined a protective covering and average height of herbage, specific structure and total number of species of plants, the index of sinantropization (a share of sinantropny types from total number) by A.M. Abramova's method [13].

Laboratory and analytical researches carried out in 3-9 multiple frequencies. The content of humus was determined by Tyurin's method in Nikitin [4] modification, pH of suspension (1:2,5) by electrometric. The activity of enzymes (invertase, urease, phosphatase, dehydrogenase) was determined by colorimetric and catalase by gasometric method by Galstyan's techniques in Haziyev's modification [14]. The received indicators were estimated by the scale by Gaponyuk and Malakhov [15]. The relative total profile enzymatic activity was calculated according to Zvyagintsev's method [16].

The physiological activity of soil microbic biomass was established using the basal and substrate - induced respiration (a BR and SIR) [17]. Definition was carried out according to methodical developments of N.D. Ananyeva [18, 19]. The preincubation of samples was carried out at optimum humidity of soils (60% of MMC) within 7 days at a temperature of 220C in plastic bags with air exchange. Quantitatively release of carbon dioxide was defined according to A.Sh. Galstyan's technique [20]. The SIR rate was estimated on the rate of respiration of microorganisms after enrichment of the soil glucose (0,2 ml/g of the dry soil; a caption of 0,05 g of glucose) and incubations during 4 hours at a temperature of 220C. For calculations of content of carbon of microbial biomass (C mic) the SIR rate expressed in ml CO2/g of soil / in hour. Cmic (mkg C/g soil) = SIR (mkl CO2/g soil/hour) × 40,04 + 0,37 [21]. The reserve of microbial biomass carbon in the 20 cm layer was calculated taking into account density of the explored soils: Cmic reserved (g/m2) = Cmic (mkg C/g soil) × d (g/cm3) × V, where the V - volume of the soil in a layer of 20 cm and the area of 1 m2 = 10000 cm2. Density of soils (d (g/cm3)) defined according to state standard specification 5180-2015.

For definition and comparison of the general level of biological activity of various subtypes of chernozemic soils used a method of calculation of the integral index of an ecological and biological state of soils (IIEBSS) [22, 23]. For finding of IIEBSS the maximum value of each of indicators in selection was taken for 100%, and in relation to it expressed values of this indicator in relative percent in other samples: Bi= Bx/Bmax×100 of %, where Bi - relative point of indicator; Bx - the actual value of an indicator; B max - the maximum value of indicator. Then summarized relative data of several indicators which absolute values cannot be summarized since have different units of measure: Bav. = (B1+B2 + ... Bp) / N, where Bav. - average estimated point of an indicator; N - number of indicators. IIEBSS was calculated by a formula: IIEBSS = (Bav. / Bav. max.) × 100%, where Bav. - average estimated point of all indicators; Bav. max. - the maximum estimated point of all indicators. At calculations used these activities of five studied enzymes, the rate of BR, reserves of humus and microbic biomass defined taking into account density of addition of the top horizons and therefore more precisely the reflecting properties of the explored soils.

Statistical processing of the obtained data was carried out in the Statistica-10.0 program. Reliability of distinction of the studied soil characteristics estimated at significance value $\alpha \leq 0{,}05$.

RESULTS AND DISCUSSION

Lying of soil cuts, sampling and the description of vegetable communities within natural biogeocenoses were carried out on sites, free from intensive anthropogenic influence. Respectively this factor had no significant effect on the studied parameters of virgin mountain chernozemic soils that causes legitimacy of carrying out the comparative analysis of natural and agrogenic soils. Justification of the studied natural meadow wholeness bio geocenoses are the lack of a trail structure, traces of journey of agricultural machinery and a pasture of the cattle and also the results of geobotanical researches which revealed high values of the general projective covering and average height of herbage, considerable specific richness of flora and also low level of sinantropization of sites [Table 2]. As a part of forb-cereal steppe meadows of all three sites types of Festuca pratensis Huds and Elytrigia repens, characteristic of the area of researches dominate (L.) Desv. ex Nevski. From forb high abundance have Galium verum L., Salvia verticillata L., Medicago falcata L., Achillea millefolium L. Cirsium ciliatum (Murray) Moench, Carduus crispus L occur among sinantropny plants single copies., Urtica dioica L.

Table 2: The geobotanical description of the studied natural biogeocenoses of Central Caucasus Mountains (in borders of Kabardino-Balkaria)

Geobotanical characteristics of sites	Sites of natural biogeocenoses		
	Zolsky district, surrounding village of Kamlyukovo	Baksan district, surrounding page V. Kurkuzhin	Baksan district, surrounding village of Islamey
General projective covering, %	90	100	90
Height of herbage, cm	30	35	40
Number of species of plants	34	30	36
Index of a sinantropization, %	2,94	3,33	5,55
Level of anthropogenic pressure	Low	Low	Low

Acid-base conditions considerably define biological activity of the soil as exert impact on chemical properties of humus and the specific structure of microbial community and also enzyme activity showing high activity in the certain range of values pH (the invertase is most active in acidic conditions, urease - in neutral, phosphatase, dehydrogenase and catalase - in alkaline) [3, 4, 16]. Comparison of the data characterizing physical and chemical properties of the compared natural and arable mountain chernozemic soils [Table 3] shows that values pH (H_2O) are in limits of genetically caused values corresponding to neutral and alkalescent reaction of soil solution.

Density of addition of natural soils is lower, than processed. In profiles of chernozemic soils ordinary and typical even in the horizon of B1 the values of this indicator <1 g/cm3 that is probably connected with action of powerful root system of grassy plants and also activity of earthworms and activity of other representatives of mesofauna. Values of density in the arable horizons can be considered close to optimum.

Down a profile of the processed soils density naturally increases, but even upon transition to maternal breed does not exceed 1,32 g/cm3 that speaks about lack of reconsolidation of the described soils as a result of processing.

Dehumification of arable soils - well studied and conventional phenomenon. The data about decrease of content and reserves of humus are provided in the plain chernozemic soils of Kabardino-Balkaria by us earlier [24-27]. The cespitose layer of natural mountain chernozemic soils is characterized by high (> 6%) humus content, however, in our opinion, it is not quite correct to compare the content of humus in the arable horizon and cespitose. Comparison of parameters of the arable horizon and the humus-accumulative horizon A is more justified.

The noticeable difference in the humus content between the arable horizon and horizon A is established only for the typical chernozem (decrease in the arable horizon makes 24%). For chernozemic soils ordinary and leached quite comparable indicators are found. Calculations of stocks of humus in layer of 0-20 cm of natural and agrogene chernozemic soils also speak about close values which can be characterized as averages: for chernozemic soils ordinary - 108 t/hectare and 110 t/hectare, chernozemic soils typical - 136 t/ha and 142 t/ha, leached - 117 t/ha and 112 t/ha respectively.

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Table 3: Profile physical and chemical indicators of mountain chernozemic soils of Central Caucasus (in borders of Kabardino-Balkaria)

Arable mountain chernozemic soils					Natural mountain chernozemic soils				
Depth of sampling of the soil, cm	Content of humus, %	Reserves of humus, t/ha	Density, g/cm^3	pH H_2O	Depth of sampling of the soil, cm	Content of humus, %	Reserves of humus, t/ha	Density, g/cm^3	pH H_2O
Ordinary chernozemic soils									
Aar. 0-20	5,3	106	1,0	7,98	A0 0-5	7,0	32	0,9	6,63
A 20-37	4,6	86	1,1	7,95	A 5-18	5,8	68	0,9	6,83
AB 37-57	4,3	102	1,2	7,97	AB 18-33	5,0	69	0,9	7,42
B1 57-76	4,0	99	1,3	8,05	B1 33-47	3,4	48	1,0	7,62
Bca 76-104	2,6	95	1,3	8,05	Bca 47-84	3,0	122	1,1	7,64
BC 104-140	2,2	94	1,3	8,03	BC 84-110	2,4	75	1,2	7,63
Typical chernozemic soils									
Aar. 0-20	5,9	142	1,2	6,95	A0 0-6	9,3	45	0,8	6,42
A 20-46	5,1	146	1,1	7,52	A 6-26	7,8	125	0,8	6,86
AB 46-67	3,7	86	1,1	7,98	AB 26-50	3,7	80	0,9	7,05
B1 67-90	2,5	69	1,2	8,21	B1 50-73	2,4	50	0,9	7,80
Bca 90-140	2,0	130	1,3	8,25	B2 73-110	2,1	93	1,2	8,28
BC 140-180	2,0	104	1,3	8,56	BC 110-140	2,0	72	1,2	8,06
Leached chernozemic soils									
Aar. 0-20	5,1	112	1,1	7,80	A0 0-5	6,5	33	1,0	7,12
A 20-38	2,2	48	1,2	8,07	A 5-30	5,1	140	1,1	7,86
AB 38-64	2,1	66	1,2	8,26	AB 30-50	3,0	66	1,1	7,97
B 64-88	1,2	37	1,3	8,33	B 50-84	1,6	60	1,1	8,33
BC 88-120	1,1	46	1,3	8,52	BC 84-130	1,0	51	1,1	8,35

Decrease in humus content down a profile for all described soils (except for the agrochernozem leached) has similar character. Upon transition from A0 horizon to the horizon A (in natural soils) and also Aar. to the horizon A (in processed) the change of indicators comes for 13-22%. Sharper decrease (rather overlying horizon) is noted in a middle part of a profile (below AB horizon) where it makes 32-47%. It should be noted that in a profile of natural and arable chernozemic soils ordinary below the horizon of B1 the differences in sizes of the described indicator are less, than in the top horizons. In chernozemic soils typical similar values take place already in the horizon of AB and further down a profile. In ordinary and typical chernozemic soils - both virgin, and arable, rather high content of humus is observed even upon transition to maternal breed. It indicates existence of an organic substratum and activity of microbiological and biochemical processes and also zoogene transfer of organic substance down a profile. The set of biological processes and also mechanical transfer of organic substance forms the stretched humic profile of mountain chernozemic soils.

In a profile of the mountain agrochernozem leached there is sharp decrease in humus content (more than twice) in the subarable horizon owing to what the data characterizing humus condition of the horizons of A and AB practically coincide. In a profile of the virgin leached chernozem so noticeable difference in the humus content between the top horizons is not observed. Below the horizon of AB the differences in values of this indicator in virgin and arable soils are leveled and in the horizon of BC make about 1%. Therefore, it is possible to make the assumption that sharp reduction of contents (and a stock) humus in the subarable horizon of this subtype of the chernozem is connected with its processing. Clarification of the reason of so sharp falling demands a separate detailed research as it is not quite clear - whether noted feature is typical for arable mountain leached chernozemic soils and also - whether it is connected with high content of mobile humic fractions in these soils.

Calculation of profile reserves of humus showed that in the compared couples of agrogene and virgin mountain chernozemic soils ordinary (respectively 583 t/ ha and 413 t/ha) and typical (677 t/ha and 465 t/ha) this indicator is higher than in the processed soils. The great values of density of addition established for all horizons of agrochernozemic soils and also more powerful profile of arable chernozemic soils ordinary and typical are the reason. Humus stocks in mountain chernozemic soils leached make for a profile of the arable soil - 309 t/ha, and virgin - 350 t/ha that, at comparable values of density and power of leached chernozemic soils, is a consequence of lower humus content in all profile of the agrochernozem.

Along with the profile researches selections of soil samples in a layer of 0-20 cm of natural and arable chernozemic soils were made. According to the obtained data, the average content of humus (the volume of selection of 16-18 samples for each subtype) in the processed chernozemic soils ordinary is 5,28±0,52%, in virgin - 8,05±0,49%; in chernozemic soils typical - 7,27±0,54% and 9,76±0,96%; in leached - 6,41±0,69% and 8,50±0,93% respectively. The given average values of the considered indicator allow judging the direction of process of change of humic state of the arable horizons of mountain chernozemic soils, in comparison with natural analogs. The decrease in humus content by 25-34% statistically significant ($t > 2,3$ is established; $p < 0,04$) for all subtypes, therefore, around a research humic degradation of the arable horizons of mountain chernozemic soils takes place.

Catalytic activity of soil enzymes is a traditional indicator of biological activity of the soil. The analysis of the obtained data confirms low activity of the studied enzymes in the processed mountain chernozemic soils. [Table 4] of the explored territories. In the arable horizons absolute values correspond to average and weak levels [15]. The exception is made by the urease showing high activity up to mountains of B1 in a profile of the agrochernozem ordinary that can be a consequence of recent introduction of nitrogen fertilizers. With a depth the activity of all enzymes gradually decreases, but, as a rule, remains (though very weak) even upon transition to maternal breed.

Comparison of absolute values of activity of enzymes in the natural and processed soils shows that activity of the oxidoreductases (catalase and dehydrogenase) participating in oxidation-reduction processes of synthesis of humic components changes as a result of agricultural influence to a lesser extent, than behavior of hydrolytic enzymes. Data are in limits of one category of activity, or decrease (in comparison with horizon A of virgin soils) from average - to weak or from weak - to very weak. Presumably, the aeration of the arable horizon of the soil happening when processing to some extent influences functioning of oxidoreductases therefore falling of their activity is not so essential compared to the representatives of hydrolase. Other authors investigating change of activity of soil enzymes under the influence of a complex of agrogene factors [1, 14, 28] also came to similar conclusions.

Table 4: Profile enzymatic activity of arable and virgin mountain chernozemic soils of Central Caucasus (in borders of Kabardino-Balkaria)

Depth of sampling of the soil, cm	Dehydrogenase, mg TFF /10g/24h	Catalase, ml O_2 /1g/1min	Invertase, mg glucose 1g/24h	Urease mg NH_3/10 g/ 24 h	Phosphatase, mg P_2O_5/100g / 1h
Arable chernozem ordinary					
Aar. 0-20	10,7	3,1	5,5	37,0	10,0
A 20-37	11,6	2,1	3,6	33,1	8,6
AB 37-57	8,8	2,6	2,0	30,3	8,5
B1 57-76	8,4	1,8	1,4	30,1	6,0
Bca 76-104	6,2	1,3	1,6	18,0	5,6
BC 104-140	1,4	0,2	0,4	4,9	3,4
Virgin chernozem ordinary					
A0 0-5	15,6	8,8	36,0	51,9	17,4
A 5-18	9,3	8,8	13,1	31,2	14,4
AB 18-33	6,4	5,6	5,9	9,3	15,3
B1 33-47	3,9	5,7	2,6	7,0	13,8
Bca 47-84	2,4	2,7	1,5	5,4	7,8
BC 84-110	0,5	0,4	0,5	3,7	3,5
Arable chernozem typical					
Aar. 0-20	2,0	5,1	9,4	14,6	13,3
A 20-46	1,6	2,1	3,8	4,4	7,5
AB 46-67	1,4	2,0	2,8	1,1	5,8
B1 67-90	1,1	0,2	1,7	0,6	4,9
Bca 90-140	0,9	0,2	1,6	0,5	4,8
BC 140-180	0,2	0,2	0,8	0	1,3
Virgin chernozem typical					
A 0 0-6	2,7	5,7	28,7	15,4	18,0
A 6-26	2,5	5,0	15,8	11,5	11,4
AB 26-50	2,2	4,3	7,2	10,5	8,7
B1 50-73	2,3	3,5	4,4	5,1	5,0
B2 73-110	2,0	3,3	3,7	1,1	5,1
BC 110-140	1,1	2,8	3,5	0	4,4
Arable chernozem leached					
Aar. 0-20	3,6	5,2	11,1	29,6	12,4
A 20-38	1,7	1,4	2,5	15,2	6,3
AB 38-64	1,3	1,0	2,1	14,3	5,6
B 64-88	0,4	0,2	2,0	1,2	5,3

BC 88-120	0,3	0,1	2,0	0,6	5,4
Virgin chernozem leached					
A0 0-5	4,1	6,7	18,7	23,6	18,4
A 5-30	3,4	6,3	10,9	15,5	10,5
AB 30-50	3,2	4,9	5,5	14,7	7,9
B 50-84	0,7	2,6	4,4	2,1	5,4
BC 84-130	0,5	1,5	4,3	1,5	4,4

Differences of activity of hydrolytic enzymes in soils agro-and biogeocenoses are shown more and are 23-84% in the top horizons. Invertase catalyzes reactions of decomposition of sucrose to glucose and fructose - the substances which are a power source and carbon for plants and microorganisms. She shows average activity in the cespitose horizons of natural soils which decreases down a profile - to weak and very weak. In the arable horizons the invertase activity is weak, and down the profile of agrogene soils is very weak.

Phosphatase plays an important role in reactions of phosphoric exchange as mobilization of the phosphorus fixed in organic substances before the connections available to plants, is carried out by rather narrow group of the microorganisms producing specific enzymes - phosphatases [16, 4, 14, 29]. Profile dynamics of this enzyme both in natural, and in the processed chernozemic soils is similar to invertase.

However not all obtained data keep within the scheme of the unambiguous decrease in enzymatic activity which resulted from agricultural use. For example, in chernozemic soils leached the activity of urease in the arable horizon is slightly higher, than in the cespitose horizon of the natural soil, and down a profile of the compared soils absolute datas of urease activity practically coincide. Dynamics of activity of urease and in a profile of the agrochernozem ordinary where its high rates in the arable soil remain to horizon BCa is non-standard and also is even surpassed by similar characteristics of the natural soil. This enzyme participates in processes of regulation of nitric exchange, catalyzing decomposition of urea on ammonia and carbon dioxide that makes urea nitrogen available for plants and microorganisms [30]. In the presence of a substratum (mineral fertilizers) the catalytic role of urease increases that, perhaps is the reason of its activization in arable chernozemic soils ordinary and leached.

To track more general regularities in change of biochemical activity of mountain chernozemic soils when agrousing, the values of relative total profile enzymatic activity were calculated. When comparing genetic analogs of virgin and arable soils it is established that indicators of total profile activity of enzymes in the natural chernozem typical are 23% higher, in leached - for 29%. In chernozemic soils ordinary the return ratio is observed. In a profile of the virgin soil the total activity of enzymes is lower, than in arable for 22%. The high activity of urease and a dehydrogenase in a middle part of a profile and also the big power of the agrochernozem ordinary is the reason of the received result.

The provided data say that influence of arable impact on activity of soil enzymes has ambiguous character. In general, processes of decrease of the activity of enzymes, both in arable, and in the underlying horizons of the processed soils prevail. However, in some cases activization of separate enzymes is observed which reasons it is difficult to establish within this work. The numerous materials of various authors analyzed by Haziyev and Gulko [30] specify that influence of agroecological factors on processes of biological circulation in the soils-plant-micro-organisms system possesses multidirectional action. In particular, it is noted that application of fertilizers leads to activization of hydrolysis of carbohydrates thanks to temporary creating favorable conditions for release of the enzymes connected with receipt and processing of a substratum. Despite a difficult picture of manifestation of various enzymes activity in profiles of natural and arable mountain chernozemic soils, this part of a research is necessary for determination of the general level of their biological activity and its change under the influence of a complex of agrogene factors.

The enzymatic activity of soils is very closely connected with functioning of soil microbic biomass therefore determination of microbiological parameters of the explored soils was a part of a research. The efficiency of use of respiratory indicators of microbiological activity when comparing of the natural and anthropogenic changed soils is confirmed by many authors [21, 2, 31, 32]. Application of the approach recommended by them allows defining extent of change of physiological activity of soil microbic biomass, relying on comparison of indicators of a BR and SIR rate of the explored soils [Table 5]. The indicators of intensity of BR characterizing the course of background breath of soil microbic biomass in profiles natural typical and leached chernozemic soils are quite close. The maximum values are tipical of the for upper horizons, however a certain makes 62-53% respectively respiratory activity of a soil microbiota remains also upon transition to maternal breed, and decrease, in comparison with the most biogenous horizon A0.
The profile of the natural mountain chernozem ordinary is allocated with the highest values of speed of BR up to horizon BCa. The considered indicators of this soil (a BR, SIR, Cmic) are significantly higher, than similar parameters of other subtypes of natural mountain chernozemic soils. Possibly, the submitted data reflect features of the concrete soil, but not this subtype in general. Average values of speed of BR in the top horizons (0-20 cm) of various subtypes of natural mountain chernozemic soils calculated on the basis of volume selection say that the distinctions established at the level of a subtype are not statistically significant ($t < 1,53$; $p > 0,16$) for mountain chernozemic soils. Chernozemic soils ordinary are characterized by BR rate = 11,5 ± 1,3 mkg CO2/1г/h; chernozemic soils typical - 13,9 ± 1,9 mkg CO2/1г/h; chernozemic soils leached - 8,6 ± 1,4 mkg CO2/1г/h.

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Values of rate of BR in profiles of arable mountain chernozemic soils are quite comparable: indicators gradually decrease down a profile, but a certain respiratory activity remains also in horizon BC. The maximum decrease, by comparison of absolute measures of the humic accumulative and arable horizons, is established for the ordinary chernozem (77%) that is explained by the BR high absolute values in the virgin soil. Easing of a BR in of intensity the similar horizons of typical and leached agro chernozemic soils makes according to 26% and 37%. As shows a detailed research of the top horizons, these values more reflect the extent of change of the considered parameter of biological activity in arable soils.

Determination of average values of BR rate in the arable horizons on the basis of volume selection showed statistically significant decrease in this indicator ($t > 3,8$; $p < 0,001$) for 29-52% in agrogene soils. BR rate in the arable chernozem ordinary is 5,5 ± 0,8 mkg CO2/1r/h; typical 5,8 ± 0,7; leached 6,1 ± 0,8 mkg CO2/1r/h. The submitted data indicate essential decrease in background respiratory activity of the soil microbic biomass which resulted from under agricultural influence.

SIR rate characterizing the potential of physiological activity of microbic biomass of the soil with surplus of a substratum and optimum conditions of temperature and humidity also shows the highest values in a profile of the virgin chernozem ordinary that, is possibly feature of the considered profile as other subtypes of natural mountain chernozemic soils are characterized by lower and close profile indicators. Aar., in comparison with the horizon A, makes decrease in intensity of SIR in the horizon: in the ordinary chernozem of 54%, in typical - 49% and in leached - 41% that confirms reduction of potential physiological activity of microbic biomass in arable soils, in comparison with natural.

Table 5: Profile microbiological indicators of arable and virgin mountain chernozemic soils of Central Caucasus (in borders of Kabardino-Balkaria)

Depth of sampling, cm	Rate of BR, mkg CO_2/1g/h	Rate SIR, mkg CO_2/1g/h	Cmic, mkg C / 1h	Cmic reserves, g/m^2
Arable chernozem ordinary				
Aar. 0-20	4,4	37,1	1487	309
A 20-37	3,8	35,8	1434	254
AB 37-57	3,6	31,2	1250	295
B1 57-76	3,7	30,3	1212	288
Bca 76-104	3,1	23,4	937	338
BC 104-140	3,1	9,6	386	183
Virgin chernozem ordinary				
A_0 0-5	18,2	121,9	4882	215
A 5-18	16,2	79,8	3193	374
AB 18-33	13,8	71,5	2863	395
B1 33-47	8,7	53,2	2129	286
Bca 47-84	9,2	45,8	1834	747
BC 84-140	2,8	32,0	1282	825
Arable chernozem typical				
Aar. 0-20	5,1	23,1	925	222
A 20-46	3,4	13,8	496	146
AB 46-67	2,4	12,4	551	126
B1 67-90	3,0	5,5	221	60
B2 90-140	2,5	2,8	111	70
BC 140-180	1,0	2,0	81	16
Virgin chernozem typical				
A0 0-6	7,8	68,8	2755	134
A 6-26	6,9	45,4	1818	302
AB 26-50	5,3	44,0	1762	364
B1 50-73	5,4	26,5	1061	131
B2 73-110	4,1	18,3	733	317
BC 110-140	3	15,0	601	216
Arable chernozem leached				
Aar. 0-20	4,9	25,4	1817	223
A 20-38	4,6	28,9	1157	246
AB 38-64	4,0	27,5	1102	344
B 64-88	3,0	24,8	1016	297
BC 88-120	2,9	11,0	441	181
Virgin chernozem leached				
A0 0-5	9,8	52,3	2093	108
A 5-30	7,8	43,0	1722	460
AB 30-50	6,4	26,6	1065	230
B 50-84	5,5	16,0	643	243
BC 84-130	4,6	13,1	523	270

Content of carbon of microbic biomass (Cmic) is calculated on the basis of data of SIR and is the reliable indicator serving as the standard index when determining quality of the soil [33]. Smik is a live and functioning part of carbon of the soil thanks to which there is a transformation of all complexes of organic substances of the soil. High content Cmic (> 1000 mkg C/g of the soil) is observed in all horizons of the virgin chernozem ordinary (up to maternal breed) and in the top half of a profile typical and leached. These contents Cmic in a profile of typical and leached agrochernozemic soils, though are inferior to the natural analogs on absolute values, belong to the category high, up to the lower part of a profile where they correspond to average and low values.

To establish degree of difference between virgin and arable soils according to contents Cmic in a layer 0-20 cm allow the average sizes calculated on the basis of data of volume selection. In natural mountain chernozemic soils ordinary Cmic makes 1926±358 mkg C/g, in arable - 1239±142 mkg C/g; chernozemic soils typical according to 1660±96 mkg with head and 1150±91; chernozemic soils leached - 1681±146 mkg C/g and 1210±121 mkg C/g. Average values speak about high content Cmic in all studied soils, nevertheless, it is established statistically significant (t> 2,65; p <0,001) decrease in a microbic indicator in the arable horizons for 28-36%.

The data characterizing the stocks of Cmic calculated for all profile of the explored mountain chernozemic soils give the chance to compare the studied soils by this quantitative microbic index. Among natural mountain chernozemic soils the chernozen is in the lead (2842 g/m2), follow it typical (1543 g/m2) and leached (1311 g/m2). Among mountain agrochernozemic soils: ordinary (1667 g/m2); leached (1290 g/m2) and typical (644 g/m2). Thus, the greatest decrease Cmic (58%) is established for the typical mountain chernozem, the difference between chernozemic soils ordinary (decrease by 42%) and the minimum change of profile contents Cmic in the leached agrochernozem (18%) is slightly less. Change of profile indicators is connected with essential decrease in intensity of SIR (and as a result of contents and stocks Cmic) in the arable horizons, in comparison with humus-accumulative. These indicators decreased on average by 48%.

As appears from the submitted data, formation of biological activity in profiles of both natural, and arable mountain chernozemic soils - difficult and multidirectional process. The considered components of biological activity of mountain chernozemic soils show various profile dynamics and ambiguously react to a complex of agroecological factors. The arable horizons bear the maximum agrogene load, and extent of change of their biological indicators can be tracked on the basis of bigger selection, based on average values of the considered parameters. Apparently from the obtained data [Table 6], in the arable horizons of mountain chernozemic soils all controlled indicators in a varying degree decreased.

To establish the general level of biological activity of the explored soils and to estimate its change in result of long-term arable influence, it is necessary to integrate all studied parameters of biological activity into uniform estimated criterion. For performance of this task the profile IIEBSS of virgin and arable chernozemic soils are defined. Besides by IIEBSS which characterize biological activity of the arable and humus and accumulative horizons (0-20 cm) of the processed and natural soils are calculated. At calculations data of humus stocks (which consider also density of various horizons of the studied soils), rate of BR, reserves Cmic (SIR considering rate, contents Cmic and density of soils) and activity of five studied enzymes were used. The IIEBSS profile values of various subtypes of natural and agrogene mountain chernozemic soils are presented in the [Fig. a].

Table 6: Decrease in average values of biological activity (for % of rather natural analogs) in the arable horizons (0-20 cm) of various subtypes of mountain chernozemic soils of Central Caucasus (in borders of Kabardino-Balkaria)

Content of humus	BR rate	Rate SIR and content Cmic	Dehydrogenase	Catalase	Invertase	Urease	Phosphatase
Ordinary chernozemic soils							
34	52	36	51	20	67	63	45
Typical chernozemic soils							
26	58	31	28	27	51	51	48
Leached chernozemic soils							
25	29	28	44	20	57	72	41

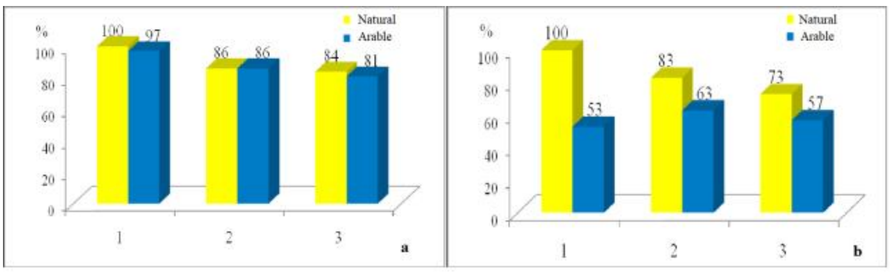

Fig. IIEBSS (%): a) profiles of natural and arable mountain chernozemic soils; b) natural and arable mountain chernozemic soils in a layer of 0-20 cm: 1. mountain chernozemic soils ordinary; 2. mountain chernozemic soils

typical; 3. mountain chernozemic soils leached. Scale of assessment of the IIEBSS level (%): up to 20% - very low, 21-40% of low, 41-60% average, 61-80% of high, 81-100% very high [22].
………

The chart reflects rather equal and high values of IIEBSS (> 80%) for all studied soils. Differences in IIEBSS values between profiles of agrogene and natural soils are practically absent. Essential differences at the level of a subtype between the explored soils are also not shown.

Noticeable easing of biological activity (for 16-43%) is established in the arable horizons (0-20 cm) of all subtypes of mountain chernozemic soils [Fig. b]. Comparing the data characterizing biological activity in the top horizons and in all a profile of natural and agrogene mountain chernozemic soils it is possible to come to a conclusion that the main changes of biological properties happen in the arable horizons, and down a profile indicators are gradually leveled. Therefore by consideration of total profile biological activity the differences between its level in arable and natural mountain chernozemic soils are leveled and the IIEBSS profile values practically do not differ.

The research of indicators of biological activity of various subtypes of mountain chernozemic soils allows tracking their profile dynamics in the conditions of natural and agricultural biogeocenoses. It is established that the compared virgin and arable chernozemic soils have common features of change of indicators of biological activity. The most biogenous are the top horizons, the horizon of A0 are in the lead in natural soils on the content of humus, microbial indicators, enzymatic activity. Down a profile absolute values of indicators decrease, but also upon transition to maternal breed the biological activity remains both in natural, and in agrogene soils. In spite of the fact that in a profile of the natural chernozem ordinary a number of indicators are higher, than in other subtypes of natural soils, the level of profile biological activity expressed through IIEBSS differs slightly (for 14-16%). The profile biological activity of various subtypes of arable mountain chernozemic soils also is approximately at one level.

The most essential distinctions of controlled parameters and the general level of biological activity are established for the top horizons of natural and arable soils. This conclusion is based not only on results of profile researches, but also on the average values characterizing the top horizons (0-20 cm) of virgin and the processed mountain chernozemic soils received on the basis of selection of 16-18 samples for each subtype. It is revealed that in the arable horizons there was a decrease in all studied indicators by 23-67%. The established distinctions (except catalase activity ($t <1,57$; $p> 0,13$) are statistically significant ($t> 2,07$; $p <0,03$). On sensitivity to arable influence the considered parameters of biological activity can be built in the following row: activity of urease (decrease on average by 62%)> activity of invertase (for 58%)> BR rate (for 46%)> activity of phosphatase (for 45%)> activity of dehydrogenase (for 41%)> the SIR rate and contents Cmic (for 32%)> the humus content (for 28%)> activity of catalase (for 22%).

CONCLUSION

Comparing the data characterizing biological activity in the top horizons and in all a profile of natural and agrogene mountain chernozemic soils it is possible to come to a conclusion that the main changes of biological properties happen in the arable horizons, and down a profile indicators are gradually leveled. Therefore, by consideration of total profile biological activity the differences between its level in processed and natural mountain chernozemic soils are leveled and the IIEBSS profile values practically do not differ. At the same time IIEBSS, characterizing biological activity of the top horizons, decreased in arable soils on average by 28%. A conclusion follows from all aforesaid that despite long-term arable use, the mountain chernozemic soils created in a belt of meadow steppes and steppe meadows under the influence of bioclimatic conditions of the Elbrus option of zonation keep the high natural potential and remain highly productive soils. The established decrease in biological activity of the arable horizons indicates the need of continuous monitoring of the state of arable mountain chernozemic soils allowing controlling intensity and the direction of processes of their change under the influence of a complex of agrogene factors.

CONFLICT OF INTEREST

Authors confirm that the submitted data do not contain the conflict of interests.

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