



Genetic Characteristics of the Soils of the Vertical Zone of the Western Tyanshan

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Abstract. In the world, scientific research is being conducted on such priority areas as determining the current state of soils and their changes under the influence of anthropogenic factors, improving their melioration state, preserving and increasing fertility. In particular, special attention is being paid to research on determining the morphogenetic features, chemical composition, and unique properties of soil formation, identifying negative conditions arising under the influence of anthropogenic factors, eliminating their consequences, improving the melioration state, as well as preserving and increasing fertility. In world practice, on issues of improving the humus state, preventing degradation processes, safe and effective ways to apply advanced agricultural technologies are being widely researched, including improving the humus state of soils as a result of technogenic and anthropogenic factors, restoring, preserving, and increasing the fertility of degraded soils, applying agricultural technologies aimed at eliminating, deteriorating the humus state and soil properties of soils under the influence of desertification processes, developing advanced solutions to prevent the acceleration of greenhouse effect processes and CO₂ emissions during global climate change. Detailed study of the main properties of soils by zonal types, humus composition and humus state, and the mechanism of humus formation in eroded virgin and riparian soils are of scientific and practical importance. However, research on the humus state of mountain and foothill soils, the mechanism of humus formation, the physicochemical properties of humus substances, elemental composition, and their fertility of the studied object has not been conducted sufficiently.

Keywords: Natural and anthropogenic factors, humus formation main types, subtypes, erosion, soils, mountain

1 Introduction

Review of foreign scientific research on the topic of the dissertation. Scientific research aimed at studying the main properties of soils by zonal types, humus state, humus composition, transformation of humus substances and mechanisms of their formation, elemental composition of humus substances, physicochemical properties is carried out in leading scientific centers and higher educational institutions of the world, including (CNPS) National Research Center of Biological Pedology (France), Center for the Study of the Environment (Germany), International Centre for Integrated Mountain Development (Switzerland), Department of Soil and Water Science University of Florida (USA), Escuela de Agronomía, Pontificia Universidad Católica de Valparaíso (Chile), Department de Chimie, Université de Montréal (Canada), Biogas Institute of Ministry of Agriculture-BIOMA (P.R. China), World Database of Soil Resources (WRB), Soils of urban, industrial, transport, mining, and military territories are studied by the International Union of Soil Scientists (IUSS), the Soil Information Group, RPG (RSG), the International Association of Soil Scientists (IAUSS), the International Society of Soil Scientists (ISSS), the International Soil Information and Reference Center (ISRIC), the V.V. Dokuchaev Institute of Soil Science, RASKhN (Russia), the K.A. Timiryazev Moscow Agricultural Academy (Russia), the Faculty of Soil Science of the M.V. Lomonosov Moscow State University (Russia), the Institute of Agriculture SALNL (Lithuania), the Uspanov Institute of Soil Science and Agrochemistry (Kazakhstan), the Research Institute of Soil Science and Agrochemistry (Uzbekistan) [1,2]. The purpose of the research is to characterize the influence of natural and anthropogenic factors on humus formation in the main types and subtypes of eroded soils formed in mountainous and foothill regions, as well as to establish the direction and intensity of quantitative and qualitative changes in the humus state of these soils, and to develop scientifically based criteria for its assessment.

2 Materials and methods

The subject of the research is soil humus, the group and fractional composition of humus, the physicochemical properties of humic acids, types of humus, elemental composition, cartogram, humus reserves, humus-forming factors, and the humus state of soils [3,4].

The research was conducted using generally accepted standard methods: genetic-geographical, lithological-geomorphological, comparative-chemical analytical, as well as profile methods. The analyses were conducted based on the methodological guidelines "Agrochemical Methods of Soil Research", "Soil Microbiology and Biochemistry", "Soil Organic Matter", "Humus Biochemistry Practicum" and "Soil Chemical Analysis Manual". Mathematical and statistical analysis of the obtained data was carried out using the variance method (B.A. Dospheov) using the "Microsoft Excel" program. The elemental composition of humic acids was determined by us using the method of M. O. Korshun, I. E. Gelman, Dumas-Pregle, in an automatic analyzer "CHN" EA 1108. Based on the weight % composition of humic acids, using the D. S. Orlov method, the atomic % of their elemental composition was calculated, and based on the

atomic percentages and atomic ratios of the elements, the degree of humic acids was established, and a graphical-statistical analysis according to D. Van Krevelin was conducted. The simplest formulas of humic acids are calculated according to D. S. Orlov. The mountain-brown soils of the studied region are subdivided into the following subtypes: mountain-brown carbonate, mountain-brown typical, mountain-brown leached. These soils are characterized by a high humus content, a thick humus horizon, a well-formed granular structure, accumulation of carbonates in the lower horizons, and a pronounced clay horizon. One of the characteristic features of mountain-brown soils is the clay content of the middle section compared to other soils. The natural conditions for the occurrence of this process in brown soils are the presence of a certain temperature and humidity. The carbonate content of the mineral part of mountain brown soils depends on the depth of their occurrence in the soil layer and the stage of soil development. In carbonate soils, the presence of carbonates in the surface part of the soil, and in typical and leached soils, the location of carbonates in the lower layer is explained by the depth and intensity of soil moisture with atmospheric precipitation [5,6].

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Mountain brown soils, distributed in watersheds, have a heavy loamy mechanical composition. The sod layer consists of light sandy loam relative to the sod horizon. Here, a series of stratification along genetic layers is observed in the distribution of mechanical

elements. In the upper layers, the amount of physical sand is very large. Therefore, they have good water permeability [7,8].

3 Results

Research on the amount of soil humus, its fractional-group composition, distribution patterns in the republic was conducted by F.Yu.Gelser, P.N.Kostichev, N.P.Besedin with students, M.A.Belousov, S.N.Ryzhov with students, [2,3,5,9,10,11,12] scientific research on the patterns of formation and distribution, properties of irrigated and riparian soils, diagnostics, transformation, evolution of soils, prevention and elimination of the consequences of degradation processes occurring in soils, as well as research on the organic matter and properties of various eroded soils of mountainous and foothill regions was conducted by H.M.Maxsudov, L.T.Tursunov, A.Khonazarov, I.Turovov, H.H.Tursunov, R.K.Kuziev, S.Abdullaev, M.M.Tashkuziev, L.A.Gafurova, G.Yuldashev and other scientists [1,2,3,4,5,8]

Mountain brown carbonate soils, in terms of the group composition of humus, differ from typical mountain brown and leached mountain brown soils by the predominance of humic acids over fulvic acids in the upper horizons, and a decrease in humic acids and an increase in fulvic acids towards the lower horizons are observed. A decrease in humic acids was observed with increasing soil erosion.

In the remaining two types of mountain-brown soils: typical mountain-brown and leached mountain-brown soils, fulvic acids predominate over humic acids in the humus composition of the soils. According to the results of the analysis of the fractional composition of soil humus, in mountain-brown carbonate soils, the fractional composition of humic acids in soil humus is dominated by the 1st fraction associated with free and mobile one and a half oxides, and in the fractional composition of the 2nd fraction of fulvic acids associated with Ca^{++} , the fraction associated with the 1st and 2nd fractions of humic acids predominates.

In terms of the fractional composition of humic acids in soil humus, typical mountain-brown soils differ from mountain-brown carbonate soils by the predominance of only the 1st fraction associated with free and mobile half-tone oxides, and in terms of the fractional composition of fulvic acids, the content of the 1st and 2nd fractions of humic acids, as well as the 1a fraction associated with free and mobile half-tone oxides, differs. In terms of the fractional composition of humic acids in soil humus, leached mountain-brown soils differ from mountain-brown carbonate and typical soils by the predominance of the 3rd fraction associated with clay minerals and stable forms of one and a half oxides, and in the fractional composition of fulvic acids, the predominance of the fraction associated with the 3rd fraction of humic acids. According to the group composition of humus in sierozem soils, fulvic acids predominate over humic acids in dark, typical, and light sierozem soils. A decrease in humic and fulvic acids is observed as the degree of soil erosion increases.

According to the results of research on determining the fractional composition of soil humus, it was noted that in the fractional composition of humic acids of humus of dark

sierozems, the 2nd fraction associated with Ca^{++} , as well as the 3rd fraction associated with clay minerals and stable forms of one- and-a-half oxides, predominate in the fractional composition of fulvic acids, the fraction associated with the 2nd fraction of humic acids. In the fractional composition of humic acids in humus of typical sierozems, the predominance of the 2nd fraction associated with Ca^{++} , as well as the 3rd fraction associated with clay minerals and stable forms of one and a half oxides, was noted in the fractional composition of fulvic acids, the predominance of the fraction associated with the 2nd and 3rd fractions of humic acids.

In terms of the fractional composition of humic acids in humus, light gray soils differ from dark and typical gray soils by the predominance of the 3rd fraction associated with clay minerals and stable forms of oxides, and in terms of the fractional composition of fulvic acids, by the predominance of the fraction associated with the 3rd fraction of humic acids. In terms of the content of non-hydrolyzed substances, the highest indicators were noted in light gray soils (55-76.3%) and typical gray soils (43.5-68.5%). According to the type of humus, (Cha:Cfa) is equal to 0.66-1.2.

The degree of humification of organic matter according to the classification (D. Orlov 2004, M. Tashkuziev 2006) in mountain-brown carbonate soils, by the degree of erosion, is 13.66%-16.87% and belongs to the low level, in the uneroded and eroded varieties of typical mountain-brown soils, it is 93.6-88.4% and belongs to the very high level, in the uneroded varieties of mountain-brown leached soils, it is 86.20% and belongs to the very high level, and the slightly and moderately eroded varieties belong to the low level. Gray soils are classified as medium and low in terms of humification. (Tables 1,2.)

To determine the relationship between soil humus state indicators, correlation coefficients were calculated. A positive correlation was noted between humus types (Cha:Cfa) and the total carbon content of the soil (C gen) of $r=0.28-0.95$, between humus types (Cha:Cfa) and the relative composition of humic acids (Cha) of $r=0.22-0.85$, between humus types (Cha:Cfa) and humic acid fractions (Cfa) of $r=0.27-0.69$, between the optical density of humic acids ($E_{\text{H}}(0,001\% \text{ ГК}@465\text{HM}, 1\text{SM})$) and humus types (Cha:Cfa) of $r=0.35-0.83$.

The correlation coefficients indicate that the humus content in the upper horizons of the soil is closely related to its group composition and the properties of humic substances, and based on the materials obtained through their integration, we can make a description of the soil types. Based on the obtained materials, the correlation between soil-forming factors and humus formation can be obtained from only one correlation indicator describing the state of humus: as the most convenient indicator, the ratio between Cha:Cfa (C humic acid :C fulvic acid) can be used.

A high release of CO_2 was observed in mountain-brown soils, where the process of decomposition of organic matter is clearly visible and closely correlates with the total number of microorganisms, and the release of carbon dioxide increases with the transition from typical and dark gray soils to mountain-brown carbonate, typical mountain-brown, and leached mountain-brown soils, depending on the exposure of slopes and their erosion. When studying the nature of seasonal growth activity of enzymes depending on the intensity of soil respiration in various subtypes of sierozems and mountain-brown soils, it was established that the activity of enzymes depends on the respiration

and hydrothermal conditions of all soils. Soil enzymes are an important link in the carbon cycle in nature. The conversion of carbohydrates into enzymes ensures the character of the inflow of a large amount of organic material into the soil, as well as the accumulation of energy in it and its transformation into humus in the soil, since its pre-humus components are formed. The enzyme of greatest interest, invertase, was active in the carbohydrate metabolism in the soil as a whole, i.e., invertase serves as a potential source for the widespread distribution of sucrose in biological organisms and its accumulation in the soil.

A large amount of energy is stored in the organic matter of the soil, which affects the intensity of biochemical processes in the soil and is a source of microbial activity. The caloric value of humic acids in the main soil types of the Western Tien Shan was calculated based on elemental composition. High indicators of the caloric value of humic acids are characteristic of sierozem soils, as they are rich in nitrogen compounds of microbial plasma. Due to the high biogenicity of sierozem soils, the caloric value was 4082-4248 cal/g. In mountain-brown soils, in winter-spring months, due to relatively high humidity, in conditions close to neutral, due to low biological activity, the ratio to C:N increases to 13-22. As a result, the caloric value of humic acids decreases sharply to 2051-3008 cal/g compared to gray soils. We studied the regularities of the chemical, physicochemical, and physical properties of humic acids in the humus of mountain-brown and gray soils. Under the influence of the erosion process, in the upper layers of the studied soils, the loss of silt fraction and a decrease in porosity, a decrease in the indicator of one and a half oxides, water-resistant aggregates, hygroscopic moisture, and maximum hygroscopic moisture were revealed. The development of erosion processes leads to a change in the elemental composition of humic acids in the soil. An increase in carbon content and a decrease in oxygen and hydrogen are observed in humic acid, which is explained by the washing away of mobile particles of newly formed humic substances. As a result, the degree of oxidation of humic acids in the studied soils changes slightly under the influence of the erosion process.

4 Conclusion

1. The brown carbonate, brown typical, and brown leached soils of the Western Tien Shan are characterized by a specific regional humus state, namely a regressive-accumulative type of humus profile, increased hydrolysis and moderate moisture content of the organic matter, the degree of humification of the organic matter (from high to weak), predominantly fulvate and humate-fulvate types of humus, and characteristic features of the fractional composition of humic acids.

2. The following regularities of the humus state of sierozem soils have been established: the unique properties of the soil-forming rock, which determine the extreme regime of soils, are characterized by low reserves of humus and nutrients; the soils of the northern exposition differ from the soils of the southern exposition by large reserves of humus and a stronger humus profile, washed, eroded, and non-eroded soils differ from eroded soils by properties corresponding to fulvate and humate-fulvate types of humus, as well as the fractional composition of humic acids.

3. In the gray-brown soil series, an expansion of the C:N ratio is observed, as a result of the high biogenicity of gray soils, it is 11.5-13.9. In mountain brown soils, as a result of relatively high moisture and weak biological activity, the C:N ratio increases to 13.7-22.0.

As can be seen from the graph in Figure 4 above, the germanium and silicon in the aluminum alloy served to increase the tensile strength of the alloy. The values of the tensile strength σ_m varied from $22.23 \cdot 10^2$ for the Al-Mg alloy to a maximum of $23.54 \cdot 10^2$. For the Al-Mg alloy, it varied from $35.78 \cdot 10^2$ to a maximum of $36.75 \cdot 10^2$. The maximum values of the samples were achieved when 2% germanium and 5% silicon were added to the alloy. Increasing the germanium content led to a decrease in its tensile strength.

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