Scientific Papers. Series A. Agronomy, Vol. LXIV, No. 2, 2021
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

CHERNOZEMS OF UKRAINE AND ITS EVOLUTION UNDER THE INFLUENCE OF ANTHROPOGENIC FACTORS

Stepan POZNIAK[1], Natalia HAVRYSH[2], Taras YAMELYNETS[1]

[1]Ivan Franko National University of Lviv, Geography Department, 41 Doroshenka Street, 79000 Lviv, Ukraine
[2]National University "Odesa Law Academy", 2 Pionerska Street, Odessa, 65009, Ukraine

Corresponding author email: taras.yamelynets@lnu.edu.ua

Abstract

Materials of researches on chernozems of Ukraine, features of their genesis, distribution conditions are generalized and analyzed. The general morphogenetic characteristics of chernozems are given, which consists in a typical habitus, constitution, posture, power, unique properties and high fertility. Stability in the development of chernozems is characterized, in particular the stage of their extensive agro-technological use, which determines the intensive development of degradation processes. The role and significance of chernozems in the world of soils as a phenomenon of nature, the ideal of soil, provider and means of labor are emphasized.

Key words*: chernozem, fertility, degradation, plowing, soil ideal, natural phenomenon.*

INTRODUCTION

Ukraine takes a leading position in the world among the countries in which chernozems are widespread. These soils occupy 27.8 million hectares, which is 8.7% of their world area, and they are the main resource for crop production. Chernozems are the main area of agricultural land in Ukraine - 67.7%. Most crops of cereals, sugar beets, sunflowers, perennial fruit, essential ether-containing crops are grown on chernozems. Chernozems are the most developed soils and potential resources for expanding arable land in the chernozem zone are almost exhausted.

As for 2012, approximately 1.32 hectares of land, 0.92 hectares of agricultural land, 0.71 hectares of arable land and 0.59 hectares of chernozem soils were per one person in Ukraine. There is only 0.19 ha of arable land and 0.045 ha of chernozem per one person in the world (Balyuk et al., 2015).

However, high yields on chernozems are obtained only in some years, and their value is lower than in Western Europe. This is due to the irrational structure of agricultural lands, sown areas, high levels of plowing, deficient balance of biophilic elements (especially C, Ca, P, K and others) due to small doses of organic and mineral fertilizers, imperfection of tillage technologies (extremely high availability of mechanical operations during plowing, sowing, inter-row cultivation, carrying out them outside the optimum humidity range, very low level of protection of arable lands by forest reclamation, hydraulic, chemical and agrotechnical measures and the prevalence of various degradations for this reason, significant littering of fields.

The chaotic type of land use with obvious negative (productive, environmental, social) consequences for future generations is due to inefficient level of legal protection of soil fertility, defective land cadastre, imperfection of state control over soil fertility (Havrysh, 2016).

The structures of chornozem soils of Ukraine are dominated by ordinary chernozems (10.9 million hectares), typical chernozems (6.2 million hectares) and southern chernozems (3.8 million hectares). Chornozems podzolized and degraded are 2.8 and 1.7 million hectares. In different natural and climatic zones, saline, residual-saline, shales and carbonate rocks occupy an area of about 3 million hectares.

RESULTS AND DISCUSSIONS

Chernozems are zonal type of soil in the forest-steppe and steppe zones, stretching from the

western to eastern borders of Ukraine. Their formation took place in two soil-climatic facies: southwestern, or warm, and central, or temperate. The chernozems of the central facies are the standard and are represented by all subtypes - from podzolic to southern. The chernozems of the south-western facies are called micellar-carbonate, because carbon dioxide salts form in them thin veins located near the surface or from the surface and boil from hydrochloric acid.

The length of the chernozem strip reaches 500-550 km from north to south. Such a significant length determines the division of chernozems at the subtype level into podzolic, leached, typical, ordinary and southern. It is established by modern researches that chernozems occur in small massifs within Polissya and Maly Polissya – they are called "island" chernozems.

Chernozems of Ukraine are characteriszed by watershed leveled and slightly sloping surfaces of interfluves and high floodplain terraces, which are formed mainly on forests and loess rocks, which cover mantle-like landforms. However, small massif of chornozems are on non-loess rocks, in particular on the eluvium of carbonate, crystalline and gypsum-anhydrite rocks, are occured.

A typical feature of chernozems is that they are confined to areas of temperate-continental climate, where evaporation often predominates over atmospheric moisture, but their predominance changes periodically.

The history of the study of chernozems of Ukraine is one of the forgotten pages of Ukrainian soil science. At the origins of the doctrine of chornozem, which preceded V.V. Dokuchaev, were Kharkiv scientists, professors N.D Borisyak and I.F. Levakovsky. N.D. Borysyak in his work "Chornozem", published in 1852, substantiated the terrestrial-plant origin of chernozems, described their properties and methods of use. Later, V.V. Dokuchaev in his famous work "Russian Chernozem", published in 1883, described in detail not only the chornozem of Ukraine but also of Bessarabia, the Volga region, the Central Chernozem zone. The Austrian scientist L. Buber made a significant contribution to the study of the chornozems of Galicia and Podillya. In 1910 his book "Chernozems of Galicia and Podillya" was published, which not only describes the natural conditions and properties of chernozems, but also their economic use. Began in the 20-30s of the twentieth century soil-geographical studies culminated in a consolidated map of soils of Ukraine, it is accumulated a huge amount of factual material with the characteristics of chornozems, which are summarized in G. Makhov's monograph "Soils of Ukraine" (Makhov, 1930).

Particular importance for Ukraine was the large-scale soil surveys conducted in 1957-1961, on the basis of which knowledge about the morphogenetic properties of chernozems, their use and measures to increase fertility, which is summarized in the monograph "Chornozems of the USSR (Ukraine)" in 1981.

Genetically, chernozem is a type of humus-calcium-montmorillonite soils with a complex and long history of soil formation process - from early hydromorphic to modern automorphic stages of development. Leading in the history of chernozem formation was a positive balance of biogenic substances and space energy, due to it a system of soil horizons was formed in the profile (Ao + A + Ark + NRk + Rk), enriched with humus, with significant reserves of nitrogen, phosphorus, potassium, micro elements. optimal which are forming water-air regime, active in-soil biological and biochemical processes. Huge reserves of potentially active chemical energy in humus, litter and living biomass, which reach 3-4 billion kcal per 1 ha and are the basis of high productivity of chernozems, their ability to withstand various environmental changes and ensure high productivity of plant photosynthesis.

Chernozems are characterized by different granulometric composition - from sandy to clay, inherited from the parent rock. They are characterized by a powerful humus horizon (150-180 cm), high content optimal parameters of structure density (1.0-1.2 g / cm3), porosity, moisture content, water permeability (200 mm / year), the provision of lyophilic elements (N, P, K, Ca, Mg, S) and micro elements.

Chernozems, like other soils, are a complex formation that is formed due to the interaction of biotic (soil biota) and abiotic (mineral) factors. Along with the root systems, which in

feathery virgin steppes reach a depth of 120-140 cm, it is active vertebrate and invertebrate organisms that process plant residues and cause the formation of biogenic emissions and coprogenic structure. Wellknown that 1 g of chernozem contains approximately 3.5 million individuals of living organisms, and 1 g of humus contains 55 million accordingly.

The best chernozem actually contains no more than 0.5% of above-ground substance, and no more than 10% of organic substance (humus). Everything else is a mineral mass. However, this mass thousands of years in the composition with chernozem is processed by living organisms. The combination of alive and inanimate gives reasons to call chernozem "the fourth kingdom of nature."

The value of chernozem lies in the content, reserves, quality, distribution of humus in the profile. No other soil can't be compared with chernozem by its content of humus. According to generalized results, humus reserves in the profiles of different subtypes of chernozems range from 192-247 t/ha - in the southern chernozems and 260-533 t/ha - in ordinary, to 260-560 t/ha - in typical and 200-410 t/ha - in podzolic.

Humus is a substance of complex chemical nature. The composition of chernozem humus includes black humic acids, which are especially important for soil fertility, and lighter and more soluble fulvic acids. These acids in chernozems are mainly connected with calcium, which gives them stability and high absorbency. According to the profile, the humus is distributed evenly, gradually decreasing to the bottom and reaching a depth of 60-80 cm in the southern chernozems and 150-170 cm in the typical chernozems of the Right-Bank Forest-Steppe of Ukraine.

Various processes take place in chernozems constantly - the transformation of substances, their migration, decomposition, dissolution, accumulation. The combination of these and many other processes is called the physiology of chernozem. These processes are dynamic, repeated day after day, from year to year, determining the rhythm of life of chernozem.

Chernozems have their own chemical properties. It contains all the elements of the periodic table, including silver, gold, radioactive elements. However, it contains the most plant nutrients that are in a form accessible to them.

Chernozem has a special habit (superficies, constitution, posture), the most perfect in the world of soils: its horizons are genetically closely related, there are no sharp transitions between them. The thickness of the dark humus profile of Ukrainian chernozem reaches 220 cm in typical chernozems.

By its nature, they are generally neutral soils, but leached and podzolic chernozems have a weakly acidic reaction of the environment. This reaction of the soil solution is favorable for most cultivated plants (Kabala, 2019; Ursu et al., 2014).

The predominance of small clay parts humic acids and movable calcium in chernozem creates the preconditions for the formation of optimal water-physical and air-physical properties. Chernozems are characterized by mechanical stability and water-resistant structure, good porosity and aeration, favorable technological properties. These natural features of chernozems determine their exceptional importance in agriculture of the world and in particular of Ukraine (Pozniak, 1997).

In Ukraine, chernozems are preserved in virgin state only in the nature reserve of Mykhailivska Tsilyna (virgin land) in Sumy region, Khomutivsky steppe in Donetsk region, Streletsivsky steppe in Luhansk and Kamyany graves in Zaporizhia region, in the Kasova Hora reserve in Ivano-Frankivsk region.

Extremely high natural fertility due to the optimal combination of circulation and accumulation of carbon, nitrogen, phosphorus, calcium is the reason for long-term use of chernozems by humans. The first anthropogenic changes in the ecology and properties of chernozems were caused by a man of Stone Age who knew the fire. Motivation, and then primitive farming, which is 2-3 thousand years old, made great local changes to chernozems. Continuous development of chernozems and the introduction of industrial machinery in agriculture during the XIX-XX centuries.

The results of research indicate that the chernozems of Ukraine have undergone significant changes over the past 100 years. At the present stage of development of soil science, the provision has been established that,

depending on the culture of agriculture, agronomically valuable properties of soils may become weaker or increase. Relatively high stability in arable chernozems of morphological parameters, molecular ratio of SiO_2: R_2O_3; the ratio of C: N, the ratio of cations in the absorption complex, indicates the stability of the parameters inherent to chernozems.

Chernozems, with few exceptions, remained untouched for millennia, as nomadic peoples dominated in the steppes. Their main task was herd cattle breeding, which provided a closed biological cycle of substances in the steppes. In the course of it, everything that was taken from chornozem returned to it. Potential soil fertility increased. This ensured the phenomenal nature of the high bioenergy of chernozem and the paradox of its stability, although human has always been very aggressive towards nature. In the seventeenth and nineteenth centuries, settled, more conscious peoples at an accelerated pace and very extensively began agricultural development of chernozems (Krupenikov, 2008).

Plowing of chernozems of the Forest-Steppe of Ukraine reaches 85%, and in the steppe it is even bigger - more than 91%. But in recent years these indexes have declined, however they still remain high. Currently, plowing of soils in Ukraine is 54%. However, the plowing of chernozems during a long time almost without the use of fertilizers has led to significant changes in the structure, composition and properties of soils. Plowing and the long process of agricultural use have changed the structure, composition and properties of soils, thereby disrupting the normal flow of energy, reducing the level of humus recovery and the release of biophilic elements connected in plant and animal biomass and soil humus. There was a loss of structure and self-compaction of soil mass. Heavy agricultural instruments intensify this process, especially on wet soils. Chernozems lose chemically bound energy in humus, aggregation and porosity, which are important for saving fertility. Over the last 40 years, so much energy has been taken from chernozems that it would be enough to boil the Black Sea (Rudenko, 2008).

Plowing, development, long-term cultivation of chernozems lead to a significant reduction (obviously not less than 2-6 times) in the number of different organisms and chernozems start to "sterilize".

As a result of chernozem acquires a clearly different physical condition and its corresponding parameters. If the compaction of root-containing horizons of chernozems increases in terms of structure density from the optimum of 1.1-1.2 g/cm^3, which is typical for chernozems to 1.4-1.6 g/cm^3, it has a negative effect on their fertility. Compaction of chernozems causes a decrease in water permeability, porosity decreases by 10-20%, the moisture of wilting of plants increases, it becomes more difficult to cultivate the soil. Drought and waterlogging have a stronger effect on compacted chernozems, causing plant oppression. Yields on compacted chernozems are reduced 15-30%, and during the consolidation to 1.5-1.6 g/cm^3 it lose 50-60%.

Plowing of chernozems promotes the development of erosion processes. The predominant types of erosion in the chernozem zone of Ukraine are water and wind erosion Eroded arable land is 30% of arable. Eroded chernozems - 25%. Among them, weakly eroded - 18%, medium eroded - 5% and strongly eroded - 2%. Erosion is a kind of guillotine of chernozems, which causes loss of habitus, reduction of humus content, deterioration of properties and generally reduction of chernozems fertility. The structure of the soil deteriorates intensively, appearing itself in the growth of boulders. On the territory of Ukraine for 130 years after V.V. Dokuchaev's research the average annual losses of humus in the arable horizon of chernozems are from 21 to 40%, or 0.5-0.9 t/ha. (Russian chernozem, 1983). For example, the content of humus in the upper 30-centimeter horizon of chernozem typical in the Mykhailivska Tsilyna is 9.5-10%, and in the same chernozems that are in agricultural use - 4.5-5%.

Long-term researches of chernozems of Ukraine have shown that the average annual losses of humus in typical chernozems are 0.7-0.9 t/ha, ordinary - 0.5-0.7 t/ha, southern - 0.3-0.6 t/ha. As a result of the dehumidification process, as well as under the influence of excessively intensive tillage with energy-intensive heavy machinery, unbalanced use of mineral fertilizers

(mostly physiologically acidic), the physical properties of chernozems deteriorate.

Extensive, irrational use, non-observance of crop rotations, reduction of perennial grasses, insufficient application of organic fertilizers, etc. significantly affect the intensity of chernozem degradation. In recent decades, the amount of absorbed calcium in typical chernozems has decreased to 26-37%, water-resistant aggregates (over 0.25 mm in size) to 33%, mineral nitrogen - to 34-40%, soluble phosphates - to 39-40%, exchangeable potassium - to 22-24% (Nosko, 2006).

In recent years, with the introduction of market-oriented sorts of wheat, corn, sunflower, rapeseed while using of modern cultivation technologies in many agricultural holdings get high yields on the large areas. However, in such fields there is an acute deficit of nutrients, especially nitrogen, and all nutrients are wasted from chernozem reserves. In this way, the laws of agriculture are violated, on the basis of which it can be stated that such management of chernozems will further reduce fertility, as chernozems can not withstand the increased capacity and predatory use (Kharytonov et al., 2004).

One of the powerful factors of human intervention in the soil-ecological system of the steppes is the irrigation of chernozems in Ukraine. If plowing and fertilizing affect mainly the upper soil horizons, then irrigation covers a much larger layer of soil-subsoil. That is why the effects of irrigation are too strong. Water, salt, heat, microbiological, gas and nutrient regimes change under the influence of irrigation. There are new processes not yet typical for chernozems - raising the groundwater level, flooding, secondary salinization, salinization, alkalization, removal of nutrients, including calcium, deterioration of physical condition, crust formation on the surface, cracking and more. In recent decades, the area of irrigated lands in Ukraine has decreased significantly and is actually 600-700 thousand hectares (Balyuk et al., 2015).

Significant damage to chernozems is caused by local waterlogging, salinization, pollution and clogging with production and consumption wastes, pollution by radionuclides and heavy metals. Irreversible damage is caused by the destruction of chernozems in the course of open-cast mining and the construction of roads, industrial and other facilities.

In recent years, an extremely important problem has arisen - the military degradation of chernozems in the Donbass. Highly productive soils are being destroyed on the territory of hostilities, chernozems have suffered and are experiencing irreparable military degradation, which leads to disruption of morphological structure of the profile, mixing of genetic horizons, changes in composition and properties, appearance of unusual inclusions in the soil - foreign bodies, shell fragments, shell fragments, intensive compaction by heavy military equipment, violation of the ground cover due to the rupture of mines, grenades, construction of trenches, dugouts, dugouts, trenches, etc., the formation of large areas of funnels, ditches, pits, violating the structures of the soil rush, its homogeneity and integrity. It is necessary to resuscitate and rehabilitate such soils in order to improve their condition. Solving of this problem will be a very important stage in the revival of Donbass.

The degradation of chernozems in Ukraine has not yet turned into a catastrophe (except for the territory of hostilities in the Donbass). It is easy to predict it, but very difficult to overcome.

Chernozem is an ideal, a standard of perfection in the world of soils in many countries around the world, including Austria and Germany. In these countries, 2005 was declared the Year of Chernozem and on this occasion in a postage stamp with the image of chernozem with a thickness of 120-130 cm was released (Altermann et al., 2005). To achieve food independence, productive soils are artificially created, taking as an example natural chernozems. In a broad sense, the welfare of Ukraine is largely based on the country's natural resources, including - chernozem - perennial breadwinner. It is no coincidence that a sample of chernozem from the Dobrovelychkivsky district of the Kirovohrad region is in the Laboratory of Land Resources of Europe as a "standard of chernozem".

CONSLUSIONS

Based on the role and importance of chernozem in nature and public life, on its aesthetic value, humanity highly appreciates this natural phenomenon. Scientific works, monographs, works of art are dedicated to him, also monuments have been built, and in some museums and educational institutions of the world there are collections of monoliths of virgin soils (Pozniak et al., 2019).

From an aesthetic point of view, chernozem is just a beautiful soil, it has an incomparable color in the virgin state, shimmers and sparkles on the edges of structural units (on the ridges of the furrow during plowing), resembling the color of a crow's wing. And even Mansell's color chart is not able to identify and name this color. In the spring plowing chernozem rises in a mirage, then falls, trembles in the spring anxiety, breathes, and all-around smells of chernozem. All these forms the aesthetic grandeur of chernozem and its ability to revive.

Being a breadwinner and a means of labor, ecological perfection and aesthetic value, chernozem is a strong and at the same time defenseless. Strength and defenselessness - such a unity of opposites is contained in chernozem.

Important conditions for increasing the productivity of chernozems, their efficient use and protection include minimizing the size of alienation of chernozems for non-agricultural use, introduction of a set of measures to prevent degradation, construction of the most advanced irrigation systems, use of irrigation water that fits the quality standards. the use of agricultural machinery, which eliminates the negative impact on the physical properties of soils, control and prevention of pollution by industrial waste and pesticides, to achieve agricultural culture in combination with a set of chemicals and land reclamation, reproduction of chernozems affected by human activities and more.

To overcome the spread of chernozem degradation, it is necessary to develop and implement legislation on soil protection, organization and realization of soil monitoring, transition to landscape-ecological land use and soil-protective agriculture.

Chernozem is a world heritage, so preserving and increasing its unique properties is an important task and responsibility for all humanity.

REFERENCES

Altermann, M., Rinklebe, J., Merbach, I., Körschens, M., Langer, U., Hofmann, B. (2005). Chernozem - soil of the year 2005. *Journal of Plant Nutrition and Soil Science*, 168(6), 725-740.

Balyuk, S. A., Truskavetskiy, R. S. (2015). System management of transformational orientation of soil fertility/*Bulletin of agrarian science* - K, No. 10. - pp.10-16 (in Ukrainian).

Demyanyuk, O. S., Sherstoboeva, O. V., Bunas, A. A., Dmitrenko, O. V. (2018). Effects of different fertilizer systems and hydrothermal factors on microbial activity in the chernozem in Ukraine. *Biosystems diversity*, 26(4).

Dmytruk, Y., Matviyishyna, Z., Kushnir, A. (2014). Evolution of chernozem in the complex section at Storozheve, Ukraine. In *Soil as World Heritage* (pp. 91-100). Springer, Dordrecht.

Havrysh, N. (2018). Use reproduction and protection of soils in Ukraine: theoretical and legal aspects. Odessa. - 396 p. (in Ukrainian).

Kabała, C. (2019). Chernozem (czarnoziem) - soil of the year 2019 in Poland. Origin, classification and use of chernozems in Poland. *Soil Science Annual*, 70(3), 184-192.

Kharytonov, M., Bagorka, M., Gibson, P. T. (2004). Erosion effects in the central steppe chernozem soils of Ukraine. I. soil properties. *Agricultura* (Slovenia), 3(1), 12-18.

Krupenikov, I. A. (2008). Chernozems. Appearance, perfection, tragedy of degradation path of protection and rehabilitation. Kishineu: Pontos. - 288 p. (in Russian).

Nosko, B. S. (2006). Antropogenic evolution of chernozems. Kharkiv. - 240 p. (in Ukrainian).

Pozniak, S. P. (1997). Irrigation chernozems of South-Western Ukraine. Lviv: VNTL. - 240 p. (in Russian)

Pozniak, S. P. (2015). Soils in the modern changing world // Coll. Science. works "Genesis, geography and ecology of soils". - Lviv, vol. 5. - PP. 202-206 (in Ukrainian).

Pozniak, S., Havrych, N. (2019). Soil in the memory of word nations. *Polish Journal of Soil Science*. Volume 52. Issue 1. P. 13-22 (in Ukrainian).

Rudenko, M. D. (2008). Energy to progress. K. - 716 p. (in Ukrainian).

The Russian chernozem - 100 years after Dokuchaev. Moscow: Nauka, 1983 - 304 p. (in Russian).

Ursu, A., Overenco, A., Marcov, I., Curcubăt, S. (2014). Chernozem: Soil of the steppe. In *Soil as world heritage* (pp. 3-8). Springer, Dordrecht.

Vysloužilová, B., Ertlen, D., Schwartz, D., Šefrna, L. (2016). Chernozem. from concept to classification: A review. *AUC Geographica*, 51(1), 85-95.

CROP SCIENCES