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GENESIS, PROPERTIES AND AMENDMENT OF PODZOLISED CHERNOZEMS OF THE WEST FOREST-STEPPE IN UKRAINE

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Abstract. This review paper introduces the Podzolised chernozems in West Ukraine. Chernozems are reputed as the most productive and fertile soils of which Podzolised chernozem takes the position of the subtype in Ukrainian system of Soil Classification and covers minor highland of Forest-Steppe areas in the west and east of Ukraine. The paper describes the local Podzolised chernozem formation factors: general climate, vegetation, topography, parent materials and areas of their distribution. It has been reported particularities of genesis, morphology and other properties of Podzolised chernozem depending of local conditions and management. Soil conservation practices of Podzolised chernozems were also outlined and discussed in this paper.

Key words: classification, organic matter, tillage, management, humus, acidity, soil structure.

INTRODUCTION

Ukrainian chernozems have been well known since the ancient times. Fertile lands to the north from black sea were mentioned for the first time by Herodotus (484 - 425 BC), Yaroslav I the Wise (978-1054 AD, Grand Prince of Novgorod and Kiev) among the other lands in Kievan Rus singled out the black lands. Vasily Vasilievich Dokuchaev in his monography "Russian Chernozem" at first conceived chernozem as an independent natural body resulting from a unique combination of climate, living matter, earthy parent materials, relief, and geological age [1].

The area under Podzolised chernozems extends from deciduous forests on the West (Pre-Carpathians) to the Central Russian upland on the North-East (Figure 1).

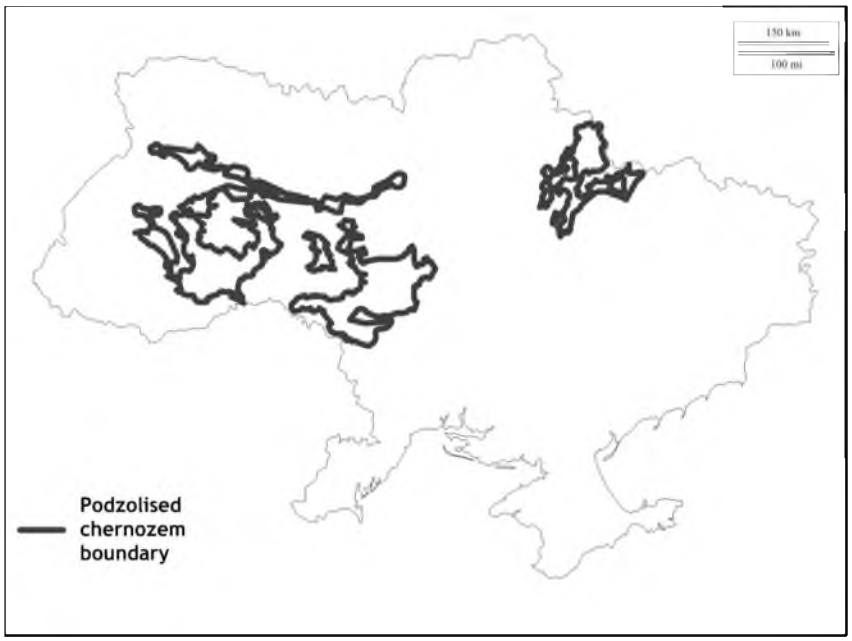

Figure 1 – Distribution of major areas of Podzolised chernozems across Ukraine

Podzolized chernozems are encountered mainly in the western regions, central part of Kyiv oblast, eastern periphery of Volyno-Podilsky plateau, in Vinnytsya oblast and northern parts of Chernigiv and Poltava oblasts. In the Left Bank of Dnipro river they are occupying some areas on the right-banks of the rivers. They do not form an unbroken band but are invading the areas of typical and leached chernozems, as well as dark grey soils on watersheds and gentle slopes. According to Tyhonenko et al. (2009) [2] Podzolized chernozems occupy 8.2 % of Ukrainian territory, 5528 ths ha (13.8 % of the total farmland area) of them are used in agriculture. The diversity of podzolized soils increases at the expense of regradation (27.8 %), erodedness (36.5 %), wetness (10.5 %), drainage (5.8 %) etc.

According to ecology- technologic grouping of Podzolised chernozems, the practices of soil tillage, fertilizer application, and plant protection are differentiated. On the slopes within 3 – 5 in steepness, row crops should not be employed in crop rotations, which (the latter) should consist of small grain crops and perennial grasses. Under conditions of erosion hazard the fields should be planned along the contours. Among the crops suitable for production on podzolized soils are winter wheat, sugar beet, com, potatoes, alfalfa, annual grasses, etc. The soils are the best for fruit trees and berries. Slightly acid reaction of podzolized soils demands regular liming. On loamy sands and sandy loams the rates of liming should be only a half of a complete rate computed by hydrolytic acidity value. On heavier soils, complete rates will not be too much, provided P_2O_5 and Zn are not bound in insoluble compounds. Farm manure should be applied at rates of 14 – 16 mt per hectare of a crop rotation per year [3].

In spite of common appearance, Podzolized chernozems vary in their morphology, properties, lithology that call forth different land use and conservation practices. The purpose of this paper is to identify the features of soil profile, parent materials, properties of West Podzolized chernozems laying down the development of local strategy their use.

MATERIALS AND METHODS

This research was conducted by the Soil Science and Soil Conservation Department of the National University of Life and Environmental Sciences in Ukraine on a Podzolised chernozem in the Forest-Steppe zone of Ukraine, near the town of Zalistchyky, Ternopil region (lat. 48° 40'54.46N, long. 25°41'10.27E). Soil profiles were dug out on the loess plateau, first terrace of Dniester river.

The soil was classified as a Haplic Chernozem according to the FAO Soil Classification, Podzolised Chernozem in Ukrainian Soil Classification, a Black Chernozem according to the Canadian system of soil classification [4] or a Mollisol according to the USDA Soil Classification [5].

Composite soil samples (five cores per composite sample) were taken from the each horizon. All soil samples were air dried and passed through a 1-mm sieve to remove the coarse mineral fraction and plant residue fragments. The gravimetric soil moisture and other soil parameters was determined for each depth increment. The determination of soil organic matter was conducted using a wet combustion technique of Tyurin [6] (1937), which is based on organic carbon oxidation by potassium dichromate (0.4 N) in acid solution (H_2SO_4 : H_2O = 1:1). Mechanical (Particle-Size) analytical procedure was fulfilled using the Kachinsky pipette method with a soil dispersion by sodium pyrophosphate solution (4 %). The soil cores were collected to determine soil bulk density. The Kappen – Gilkovitz procedure were used for Cation Exchange Capacity determination. pH_{KCl} were determined potentiometrically in soil suspensions with soil to 1N KCl ration 1:5 [7].

RESULTS AND DISCUSSION

Chernozem definition

Chernozems (Mollisols) are identified by a thick, dark-colored, humus and base-rich surface horizon (mollic epipedon), a high base saturation (≥ 50 percent by ammonium acetate) to 1.8 m depth and an exchange complex with dominance of clay minerals with permanent charge and calcium as main exchangeable cation [8]. They generally contain a significant content of weatherable minerals. In the strict sense, there are nine criteria defining the mollic epipedon with the details of the criteria varying in response to several other soil features [9]. In reality, mollic epipedons are quite straightforward. They are mineral horizons at least 25 cm thick having (a) structure, (b) moist color with both chroma and value being 3 or less, and (c) at least 50 % base saturation, and 0.6 % organic carbon content [10, 11].

Soil forming factors

Podzolised chernozems are formed in the temperate short with a relatively brief freezing period. In general, the climate in the west is semi-humid or humid. The amount of solar radiation is within 102–112 kcal·cm^{2}yr^{-1}. Mean January temperature is (-) 4-6^{0}C. Mean July temperature is (+) 18-21^{0}C. Average annual temperature from +7.2 till + 7.8^{0}C. The maximum depth of frost penetration is within 28-54 cm. Above zero temperature duration is 250-260 days and 210-215 days exceed 5^{0}C. The sums of the temperatures exceeding 10^{o}C are equal to 2500 and 2800^{0}C respectively. The average amount of precipitation is within 550-640 mm. The ratio between the average annual amount of precipitation and average annual evaporation from the open water surface (coefficient of humidity, K_h) within 0.9-1.3. The western regions of the Podzolised chernozems zone are more moist and humid, while the eastern ones are more arid and continental in climate. The vegetation types found on chernozems are oak-maple-lime-hornbeam forests with grasslands and meadows. Parent materials are characterized by "lithologic uniformity" represented by the loess and loess-like loams. The topography of Podzolised chernozems is dominantly plainland but nonuniform in both genetic and structural respects. The lowland in the south zone gradually turns into a number of uplands (150-360 m above sea level): Bessarabian, Podilska, Pridniprovska. Toward the north, Pridniprovska, Donetsky lowland and Poltavska plainland spread on the left bank of Dnipro river. The north borderline of Podzolised chernozems verges on the Polisska lowland.

Local features of factors forming Podzolised chernozems

West Podzolised chernozems begin its distribution on interfluve area between the Stryp and the Syret rivers and go forward to the plateaus of Zalistchyky and Zboryv cities. The profiles of these soils bear the mark of modal Podzolised chernozem (Figure 2) formed on medium loam loess (Figure 3a).

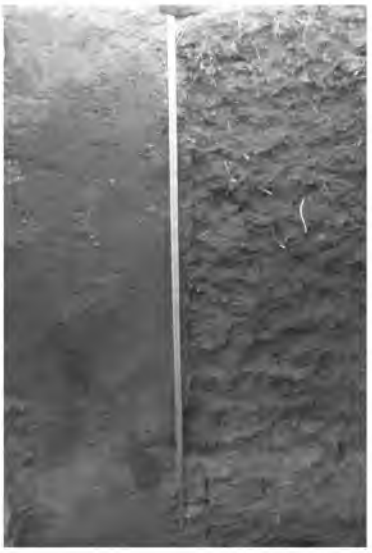

Figure 2 – The soil profile of modal Podzolized chernozem near Zalistchyky city

He 0-41/41 cm – slightly eluviated horizon of SOM accumulation; dark grey, displaying whitish dusting of amorphous SiO_2 on drying; plow layer - cloddy with powdery grains; a layer below it — nutty

with grains and clods; slightly compacted; transition gradual;

Hpi 41-89/48 cm – upper transitive slightly illuviated horizon, dark grey; granular/cloddy with nuts; compacted; with a weak amorphous silica dusting; brownish tint from the colloids of R_2O_3, earthworm channels and «crotovinas» (mole tunnels); transition gradual;

Phi 89-127/38 cm – lower transitive slightly illuviated horizon; yellow grey brown; nutty-prismatic; with R_2O_3 coatings (films) on the feces of soil aggregates; sticky, humus encrustations, plant roots, transition gradual;

P(h)i$_к$ 127-158/31 cm – slightly illuviated leached from carbonates horizon; with streaks of humus; dirty dull-grey with brownish tint; rare «crotovinas»; transition sharp along the wavy line of effervescence with 10 % HCl;

P$_к$ 158-196/38 cm – parent material; straw-colored, loess with veins of $CaCO_3$ enriched with dark mole tunnels.

At a distance of 1.1-1.4 km downward the slope appears the red argillites of upper Silurian period (Figure 3b), which towards to the Dniester river intermix with ancient alluvium (Figure 3c). Nearby the Dniester levee, parent material washes out of clays, enriches with modern alluvium and becomes lighter and yellowish (Figure 3d).

Figure 3 – The parent materials of Podzolized Chernozems depending the relief position: a – loess, b – red argillites, c – clays with ancient alluvium, d – modern levee alluvium with the traces of clays and loesses

Properties of Podzolised chernozem

Soil texture in chernozem varies from light loam to heavy loam and become heavier from the north to the south. Coarse silt and clay are dominant soil particles, but differ in their distribution. The percentage of particles 0.05-0.01 mm varies from 53.4 % in upper horizon to 41.6 % in the bottom. The distribution of <0.01 mm particles down soil profile is uniform with the minor tendency its accumulation in He horizon (Figure 4a). The content of soil organic matter (SOM) in Podzolised chernozem gradually declining through soil profile: 3.3 %, 3.2 %, 3.2 %, 3.1 %, 2.9 %, 1.9 %, 1.5 %, 1.2 %, 0.5 %. Abandoned for 40 years chernozem possess with higher humus content (4.7 – 4.5%) in 0-15 cm layer than ploughing one (3.3 – 3.2 %) (Figure 4b). Humus type (a ratio of the carbon content in humic to fulvic acids, Cha/Cfa) changes respectively from 1.2 to 0.8 or is fulvate-humatic in the upper and humate-fulvatic in the lower horizon of soil profile. The bulk density in chernozems depend on humus content and soil texture. It was found in the favorable ranges for plant growth – 1.16 – 1.3 g cm^{-3} (Figure 4c). Slightly illuvial horizons increase soil compaction considerably compared to ploughing horizon because of reduction SOM, increasing colloidal com-

pounds Al^{3+} and Fe^{3+}, metamorphism activity, nutty-prismatic aggregates, etc. Ukrainian chernozems, as a rule, have a neutral reaction, with soil pH ranging from 6.6 to 7.5. By pH_{KCl} and hydrolytic acidity Podzolised chernozem is slightly acid in the upper horizon (Figure 4d,e). The comparatively higher amount of physical sand (>0.01 mm) and lower amount of OM have resulted medium level of cation exchange capacity (CAC) in Podzolised chernozem (Figure 4f). Ca^{2+} usually makes up 95 % of all soil cations.

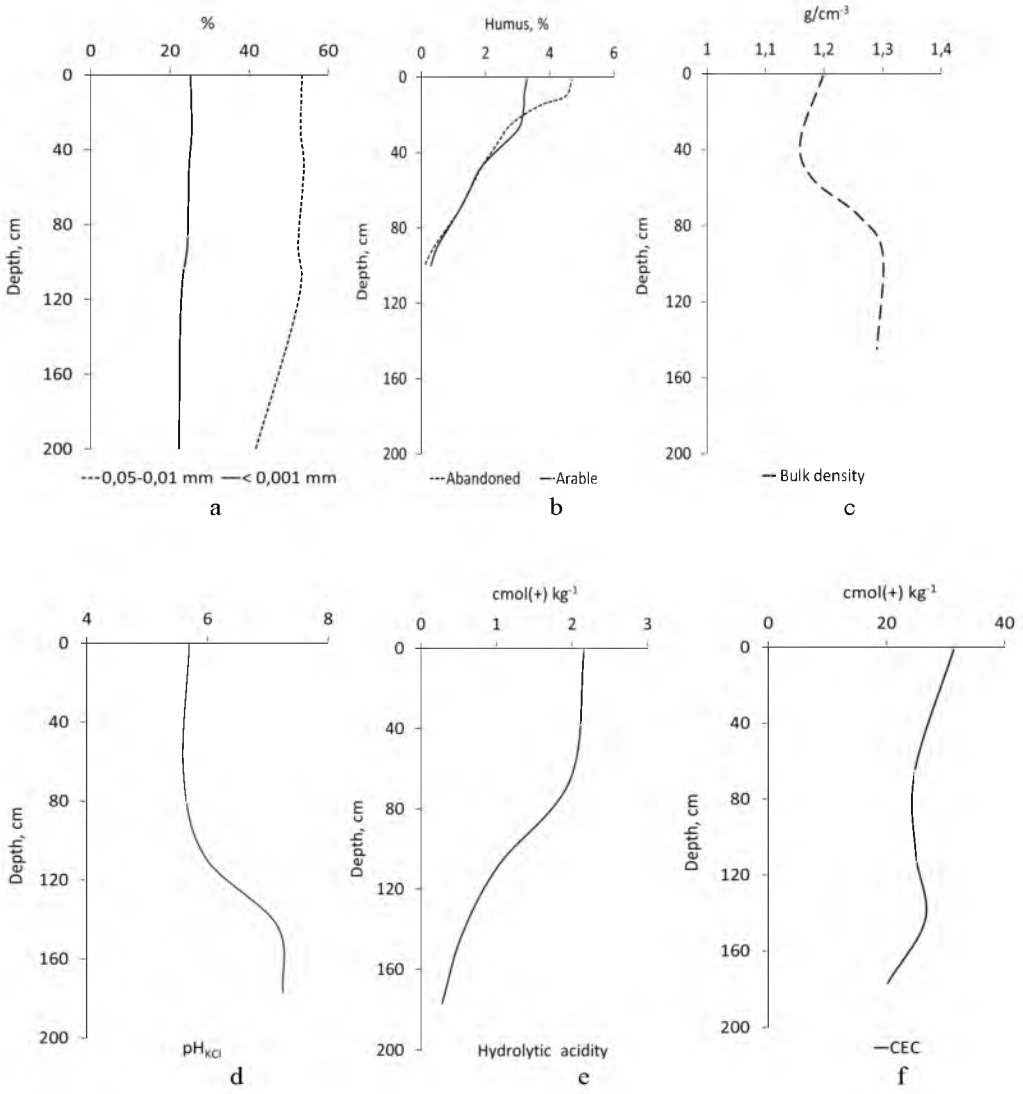

Figure 4 – Profile distribution of Podzolised chernozem properties: a – coarse silt and clay content; b – humus content in abandoned and arable soils; c – bulk density; d – exchangeable pH_{KCl} acidity; e – hydrolytic acidity; f – cation exchange capacity

CONCLUSION

Podzolised chernozem is distributed in the Forest-Steppe area, and is mostly formed under temperate and freezing zones. Parent material is represented by the loess, but regional conditions may influence soil profile by clays, shists, limestone, alluvial deposits. Soil texture varies from light loam to middle loam. Coarse silt and clay are dominant soil particles but

differ in distribution. Chernozem have an accumulative type of OM distribution in soil profile. The soil have a slightly acid reaction in the upper horizon and neutral or slightly alkaline in the bottom, medium level of cation exchange capacity. Podzolised chernozem have been primarily used in Ukraine for growing winter wheat, barley, corn, sugar beet, and sunflower. Soil properties have been changed by different management. The eminent changes are decline in soil organic matter and soil thickness, while the water and wind erosion as well as soil compaction are also becoming serious. Practices that favor conservation of the soil resource is urgently needed to guarantee food security.

ACKNOWLEDGEMENTS

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ТҮЙІН

Матвеев А., Кравченко Ю.

УКРАИНАНЫҢ БАТЫС ОРМАНДЫ ДАЛАСЫНДАҒЫ КҮЛГІНДІ ҚАРА ТОПЫРАҚТАР ГЕНЕЗИСІ, ҚАСИЕТТЕРІ ЖӘНЕ ОЛАРДЫ ЖАҚСАРТУ

Украинаның Ұлттық биоресурстар және табиғатпайдалану университеті, топырақтану және топырақ қорғау кафедрасы, 03041 Киев, Сталинград батырлар көшесінің қорғанысы, 15, Украина, e-mail: kravch@i.ua, annytas89@mail.ru

Осы берілген жұмыста Украинаның күлгінді қара топырақтары көрсетілген. Қара топырақтардың барынша құнарлы топырақ болып есептелетіні белгілі, олардың ішінде

Украинаның топырақ классификациясына сәйкес, Украинаның батыс және шығыс орманды дала бөлігінде айрықша көп қалыптасқан, күлгін қара топырақтар типшесі ерекшеленеді. Мақалада жергілікті қара топырақ факторлары суреттеледі: климат, өсімдік жамылғысы, жер бедері, топырақ түзуші аналық жыныс, сонымен қатар олардың таралу аумағы. Жергілікті жағдайлар мен олардың пайдаланылуына байланысты күлгінді қара топырақтар генезисіне, морфологиясына және басқа да қасиеттеріне сараптама жасалынды. Күлгінді қара топырақтарға қолданылатын топырақ қорғау технологиялары сипатталды және талқыланды.

Түйінді сөздер: классификация, топырақтағы органикалық заттар, орманды балшық, топырақ өңдеу, пайдалану.

РЕЗЮМЕ

Матвеев А., Кравченко Ю.

ГЕНЕЗИС, СВОЙСТВА И УЛУЧШЕНИЕ ПОДЗОЛИСТЫХ ЧЕРНОЗЕМОВ ЗАПАДНОЙ ЛЕСОСТЕПИ УКРАИНЫ

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В данной обзорной работе представлены подзолистые черноземы Украины. Черноземы как известно являются наиболее плодородными почвами, среди которых выделяются подтипы подзолистых черноземов согласно Украинской классификации почв, сформированные преимущественно на возвышенностях лесостепи в западной и восточной части Украины. В статье описываются локальные черноземные факторы: климат, растительность, рельеф, почвообразующие породы, а также районы их распространения. Проанализированы особенности генезиса, морфологические и другие свойства подзолистых черноземов в зависимости от местных условий и их использования. Описаны и обсуждены почвозащитные технологии, которые принимаются на подзолистых черноземах.

Ключевые слова: классификации, органическое вещество почв, лессовидный суглинок, почвенная обработка, использование.