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Nutrient content in grey forest soils of Husiatyn Forestry

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Abstract. The purpose of the study was to determine the physical and chemical features of various types of forest soils and assess their agrochemical state on permanent nurseries, arable land, and 30-year-old common oak crops in the conditions of the Husiatyn Forestry of the Chortkiv Forest District. Soil and agrochemical analysis methods were applied, including determination of fractional and mechanical composition, humus content, base saturation, and absorption complex capacity. The indicators were compared between light grey, grey-loamy, and gleyed soils, which allowed characterising their productivity and agrochemical potential. It was found that in most soils, the upper horizons were acidic (pH 3.6-5.0), which negatively affects the availability of nutrients, and in light grey soils, the humus content was low (0.5-1.2% in the upper horizons). In grey loamy and gleyed soils, there is more humus (1.2-2.0%), especially in arable variants (1.8-2.0%). The total nitrogen in the upper horizons was 0.1-0.18%, which is rather low. The C:N ratio was close to 8, which indicates rapid mineralisation of organic matter. Some areas were well provided with P_2O_5 (20 mg/100 g), but there were soils with a deficit (<10). Potassium supply was more stable, but depletion was possible in arable horizons. Phosphorus (P_2O_5): ranged from very low values (3.75-10 mg/100 g) to elevated values (20 mg/100 g in arable land). Potassium (K_2O): was at the level of 10-14 mg/100 g, but in some cases decreased to 5-6 mg/100 g (deterioration of supply). Hydrolysed nitrogen: values of 3.6-11.5 mg/100 g, which indicated an average or low nitrogen supply. The results of the study of the fractional and mechanical composition of soil in oak forests, using the example of the Husiatyn Forestry, are of considerable

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practical importance for the development of recommendations regarding the specifics of planting forest crops in this region and protecting the soil from erosion processes

Keywords: genetic horizons; fractions; humidity; capacity; nutrients

Introduction

The establishment of formal links between the natural environment and soil properties indicates the dynamism of a number of soil indicators: acidity, density, humus content, and metabolic substances. Quantitative indicators of the distribution of trace elements in the soil of artificial origin show their similarity to natural plantings. For example, the high concentration of titanium and the nature of its distribution in the soil and bedding of natural forests correspond to artificial plantings. This is conditioned by the influence of soil formation, which is widely represented by heavy loess-like loams and clays (Panas, 2019).

A number of Ukrainian and foreign researchers have studied the content of nutrients in grey forest soils in different years and in different regions. O. Dmitrenko *et al*. (2021) investigated nitrogen content in grey forest soils. The researchers analysed the dynamics of mineral nitrogen content depending on the use of organic, mineral and combined fertilisers. They also evaluated the effectiveness of land reclamation agents in increasing soil fertility. The results obtained allowed optimising the fertiliser system to increase the productivity of agrocoenoses. S. Ryazanov *et al*. (2025) emphasised the importance of investigating fluctuations in nutrient content and their impact on fertility. After analysing the content of macro- and microelements in the soil depending on plant species and growing conditions, the researchers paid special attention to the influence of energy crops on soil fertility and their ecological state. The data obtained were important for the rational use of land and the development of bioenergy. A. Pavlichenko *et al*. (2023) investigated fluctuations in humus content in grey forest soils, depending on the intensity of anthropogenic load on them. They carefully analysed changes in the content of humus and its fractions depending on the intensity of agricultural use. It was shown how different agricultural systems affected the quality and stability of organic matter. The results of these studies emphasised the importance of rational management of soil resources to preserve their fertility.

F. Brovko *et al*. (2023) determined the ratio of quantitative and relative indicators that significantly affect the physical properties of grey forest soils, and also found changes in compacted soil during natural recovery. Investigating changes in the density, porosity, and water permeability of the soil under the influence of prolonged recreational load, the researchers found that intensive trampling worsens the structural state and water regime of soils. And this is important for assessing the ecological sustainability of forest ecosystems and planning their rational use. L. Jinglei *et al*. (2025) studied the effect of slope steepness on the degree of drying of grey forest soils and on the sensitivity of young trees to drought along altitude gradients in temperate artificial forests. The researchers found that trees react differently to moisture deficiency on slopes of different exposures, but the speed of their recovery after a drought did not depend on the slope. The study emphasised the importance of topography as a factor determining the resistance of young plantings to climatic stresses. As a result of their research, the dependence on steepness and sensitivity to moisture was revealed, which was important for improving forestry practices in the face of climate change.

Investigating the influence of anthropogenic load of grey forest soils on their water content and the morphology and water-physical parameters of sections of light grey forest soils in the zones of anthropogenic trampling of the island, O. Brovko *et al.* (2025) established how changes in rock composition and humidity affect the distribution of root mass in the profile, and its moisture capacity, water permeability, and aeration. Studies have shown that under the influence of recreational stress, conditions for the development of woody plant roots worsen. The results obtained are important for assessing the ecological state of forest ecosystems and planning measures for their restoration. O. Kovalyova *et al.* (2021) found changes in the thickness of the humus horizon in grey forest soils depending on landscape and morphological conditions. The researchers revealed a pattern of fluctuations in the thickness of the humus profile of grey forest and chernozem soils depending on the duration of their agricultural use. As a result, it was found that the intensity and duration of agricultural use cause a decrease in humus reserves and deterioration of soil structural properties, which is important for assessing degradation processes and preserving the fertility of arable land.

However, no studies were found on the content of nutrients in soils and the impact on the composition and productivity of plantings in the conditions of the Ternopil Oblast. Therefore, the purpose of the study was to investigate and compare the physical and chemical features of different types of forest soils, their fractional and mechanical composition on permanent two nurseries, arable lands, and 30-year-old oak crops.

Scientific originality of the results obtained – for the first time in the conditions of the Husiatyn Forestry – consisted in a mechanical and physico-chemical analysis of the most common soil types. The conducted studies were particularly relevant for understanding the development of the root system of tree stands.

Materials and Methods

The object of study was the physical and chemical composition of soils in soil sections of permanent nurseries, arable lands, and 30-year-old common oak crops in the Husiatyn Forestry of the Chortkiv Forest District. This forestry was located in the southern part of Western Podillia,at the junction between the Ternopil Plateau geomorphological zone in the north and the Dniester Canyon in the south. The type of forest conditions was wet oak forest. Forests in the study region were represented by both pure deciduous stands and mixed and pure coniferous stands, which include such main tree species as common oak (*Quercus robur* L.) and sessile oak (*Quercus petraea* (Matt.) Liebl.), European ash (*Fraxinus excelsior* L, Norway maple (*Acer platanoides* L.), and field maple (*Acer campestre* L.), common hornbeam (*Carpinus betulus* L.), small-leaved linden (*Tilia cordata* Mill.), field elm (*Ulmus minor* Mill.), Scots pine (*Pinus sylvestris* L.), European spruce (*Picea abies*), European larch *(Larix decidua* L.), silver birch *(Betula pendula* Roth), common aspen (*Populus tremula* L.), and a number of other trees. The plantings of natural origin contained: field elm (*Ulmus laevis* Mill.), wild cherry (*Cerasus avium* L.), common pear (*Pyrus communis* L.), European wild apple (*Malus sylvestris* Mill. Common shrubs included common hawthorn (*Crataegus monogyna* Jacq.), common hazel *(Corylus avellana* L.), common dogwood (*Cornus sanguinea* L.), European spindle (*Euonymus europaeus* L.) and warty spindle (*Euonymus verrucosus* L.), wayfaring tree (*Viburnum lantana* L.) (Hamkalo, 2009). The research region was located in a humid continental climate with warm summers and mild winters. The average annual temperature ranged from +7-8°C. The air temperature was -4.5°C in January and +19°C in July.

Samples for research were taken in the spring-summer period of 2025. Subject of research – methods and tools for assessing the features of the distribution of physico-chemical indicators over the soil horizons of the most common types of forest soils, which would allow improving the agrotechnological processes of growing planting material on them in the Husiatyn Forestry of the Chortkiv Forest District. From four soil sections, 60 soil samples were selected for laboratory analysis, at the following depths (cm):

1. Light grey forest clay-loamy soil – HA: 0-26; Iha: 30-40; P:115-125; Pk: 150-160.
2. Grey forest loamy soil (permanent nursery) – HA: 0-28; Iha: 35-45; I: 65-75; P: 115-120; Pk: 142-152.
3. Grey forest clay-loamy soil (permanent nursery) – HA: 0-26; Iha: 30-40; I: 65-75; P: 115-125; Pk: 150-160.
4. Grey forest clay-loamy soil (arable land) – HA: 2-26; Iha: 34-45; I: 65-75; P: 125-130.

The boundaries of genetic horizons were determined by the change in colour from light grey to dark grey or brown, depending on the humus content and redistribution of iron compounds. As well as the structure that changed from lumpy in the upper horizons to denser or powdery in the deeper layers. Soil sampling was carried out with special knives in sealed bags labelled with the place of collection and the soil horizon from which the sample was taken.

Determination of the physical, chemical and mechanical properties of soils was carried out in the soil and chemical laboratory of Uman National University using the methods described in the soil science workshop (Tyhonenko, 2005). The mechanical composition of soils and the classification of loamy varieties were determined by the method of M. A. Kaczynski. The content of hygroscopic moisture was determined by drying at a temperature of 105°C. The acidity of soil solutions (pH in water and salt extracts) was measured using a pH meter. The sum of exchange bases and hydrolytic acidity were determined by the method of G. Cappen-Gilkowitz. The humus content was estimated by the method of I.V. Tyurin. Determination of mobile phosphorus (P_2O_5) were performed according to the method of A.G. Kirsanov in non-carbonate samples and according to the method of V.P. Machigin in carbonate samples. Mobile potassium (K_2O) was determined by the method of Ya.V. Peive and O.A. Brovkin in non-carbonate samples and according to the method of P.V. Protasov in carbonate samples. Total nitrogen was determined by the method of I.V. Tyurin and M.M. Kononova or method of Kjeldahl, and hydrolysed nitrogen – according to the method of Tyurin-Kononova. The content of calcium and magnesium was determined by complexometric titration, the exchange sodium – by flame photometry, and the carbon dioxide of carbonates – by the gas-voluminometric method. The cationic exchange capacity was calculated using the method of E.V. Bobko and D.A. Aksinazi, and the indicators of water extraction – according to the method of K.K. Gedroits. The ash content of the forest floor was determined by incineration, based on DSTU 7942:2015 (2015).

According to this standard, the selected and pre-dried soil sample is placed in a mortar and burned until the organic matter is completely burned in a muffle furnace at a temperature of 550°C, for two hours. Next, the sample is cooled and weighed to determine the ash weight. Ash content is calculated as the percentage of dry soil weight that remains after burning. The study followed the ethical standards and principles defined by Convention on Biological Diversity (1992), which guarantees the rational and safe use of natural resources. The entire cycle of analysis of physico-chemical studies was carried out in three-fold repetition. After that, the least significant difference (LSD) was calculated to determine the reliability of the conducted studies.

Results and Discussion

Light grey and grey forest soils in the research region were formed under broad-leaved forests on carbonate or loessial rocks. In grey podzolic soils, compared to light grey ones, the podzolic process of soil formation is less pronounced, so there is no alluvial horizon. The nutrient content of these soils, especially light grey ones, is low. The humus horizon is of low capacity, with a humus content of 2.9-3.1%. The soils are acidic, so they require lime application in small and medium doses (1.5-6 tonnes of lime per 1 hectare) (Ivanyuk, 2013). As can be seen from Table 1, grey forest soils on loessial and loess-like loams have formed such soil types as light grey forest gleyed loam, grey forest loam, and grey forest gleyed loam.

Table 1. *Statement of results of physico-chemical analysis of soils of the Husiatyn Forestry of Chortkiv Forest District in the Ternopil Oblast*

Numbers of compartment, subdivision	Numbers of sections	Genetic horizons	Sample depth, cm	Humidity, %	Silt < 0.001 mm	Physical sand sum of particles >0,01 mm	Physical clay sum of particles <0,01 mm	salt pH	mg-Eq/100 g of soil: sum of exchange bases	mg-Eq/100 g of soil: hydrolytic acidity	mg-Eq/100 g of soil: capacity of soil absorption complex	Degree of saturation with bases, %	Humus according to Tyurin, %	Gross nitrogen %	CN	Mg per 100 g of soil: P_2O_5	Mg per 100 g of soil: K_2O	Mg per 100 g of soil: hydrolysed nitrogen
Grey forest soils on loessial and loess-like loams																		
Light grey forest gleyed-loamy soil																		
109/1	221	HA	2-30	0.80		60.88	39.12	3.6	5.07	9.2	14.27	36	1.25					
		Elh	30-40	1.31		63.73	36.27	3.6	6.45	8.6	15.05	43	0.50					
		I	60-70	2.88		54.63	48.37	3.6					0.46					
***LSD*$_{0.5}$**				*2.34*		*2.97*	*2.88*	*2.18*	*2.11*	*2.01*	*2.24*	*2.03*	2.02					
Grey forest loamy soil																		
92/3	183	HA	0-28	1.88		66.60	33.40	4.3	7.51	4.0	11.51	65	1.22	0.11	6	3.75	10.5	9.48
Permanent nursery		Elh	35-45	2.24		63.00	37.00	3.9	10.23	4.6	14.88	69	0.71	0.06	7	5.0	10.5	5.60
		I	65-75	4.27		55.00	45.00	4.0					0.61					
		Pi	110-120	2.04		53.23	46.77						0.47					
		Pk	142-152	1.31		51.15	48.85	8.1										
***LSD*$_{0.5}$**				*2.67*		*2.17*	*2.44*	*2.65*	*2.96*	*2.17*	*2.21*	*2.27*	*2.16*	2.01	2.00	*2.19*	*2.35*	*2.23*
Grey forest clay-loamy soil																		
95/2	163	HA	0-26	3.09	14.81	68.7	31.26	4.1	7.26	5.4	12.66	57	2.01	0.18	6	10.0	10.5	11.48
Permanent nursery		Iha	30-40	4.16	18.92	63.3	36.67	4.5	7.30	3.9	11.2	65	0.62	0.04	8	5.00	8.40	9.24
		I	65-75	6.38	25.05	54.4	45.53	4.0	13.31	4.7	18.01	74	0.55					
		Pi	115-125	4.16	22.88	57.1	42.82	4.6					0.41					
		Pk	150-160	4.16	19.42	57.0	42.95	8.0										
***LSD*$_{0.5}$**				*2.17*	*2.77*	*2.98*	*2.19*	*2.56*	*2.32*	*2.23*	*2.61*	*2.33*	*2.34*	*2.07*	*2.03*	*2.98*	*2.62*	*2.26*
Grey forest clay-loamy soil																		
22/2	44	HA	2-26	2.563	21.32	57.0	43.00	6.5	15.81	1.1	16.91	93	1.88	0.13	8	20.0	10.5	3.64

Table 4. *Continued*

Numbers of compartment, subdivision	Numbers of sections	Genetic horizons	Sample depth, cm	Humidity, %	Silt < 0.001 mm	Physical sand sum of particles >0,01 mm	Physical clay sum of particles <0,01 mm	salt pH	mg-Eq/100 g of soil			Degree of saturation with bases, %	Humus according to Tyurin, %	Gross nitrogen %	CN	Mg per 100 g of soil		
									sum of exchange bases	hydrolytic acidity	capacity of soil absorption complex					P_2O_5	K_2O	hydrolysed nitrogen
Arable land		Iha	34-45	3.62	26.24	57.3	42.66	5.8	16.66	1.6	18.26	91	0.57	0.04	8	8.75	10.5	5.88
		I	65-75	3.84	31.82	50.08	49.92	5.9	20.33	1.3	21.63	94	0.55	0.04	8	6.25	14.0	3.64
		Pk	125-130	2.98	26.19	57.7	42.25											
$LSD_{0.5}$				*2.84*	*2.62*	*2.32*	*2.82*	*2.22*	*2.34*	*2.34*	*3.01*	*2.74*	*2.43*	*2.06*	*2.01*	*2.96*	*2.16*	*2.21*

Note: genetic horizons: HA – humus-alluvial; Iha – alluvial slightly humus and weakly illuviated; I – illuvial; Pi – transitional to illuvial rock; Pk – soil-forming parent rock

Source: compiled by the authors

Studies have shown that in 30-year-old common oak cultures created on light -grey forest gleyed loamy soils in the fresh oak forest of the Husiatyn Forestry, during the first 10 years, common oak and European ash trees had the same growth energy in terms of height, and only in the previous 5 years the increase in height of oak trees decreased slightly, while their diameter, on the contrary, increased. At the age of 30, plantings were formed by composition 3Co7E-hEaNmFe, plant density – 0.8, quality class – 2. Oak trees reached an average height of 11.2 m, an average diameter of 8.5 cm, and European ash trees reached an average height of 12.2 m and 9.6 cm, respectively. The stemwood reserve was 80 $m^3 \cdot ha^{-1}$. The presence of three genetic horizons was found by making a soil section to a depth of 80 cm. This HA horizon was 2-30 cm deep, darkish-grey, grainy-lumpy with plate-like division, slightly compacted, the transition was clear, the humidity of the genetic horizon was 0.8%. In soil, physical sand and physical clay are two groups of particles that form fine soil. Physical sand consists of particles ranging in size from 1 mm to 0.01 mm, while physical clay consists of particles less than 0.01 mm in size. The sum of sand particles >0.01 mm was 60.88%, and the sum of clay particles <0.01 mm was 39.12%, the salt pH was 3.6, the degree of saturation with bases was 36%, and humus according to Tyurin was 1.25%. Studying the content of physical and chemical elements in the soil layer of the elluvial weakly and unevenly humified horizon with a depth of 3040 cm, which is dirty brown, spotted, with humus deposits, dense, with a gradual transition (Elh), it was established that its moisture content does not exceed 1.31%. Physical sand consists of particles ranging in size from 1 mm to 0.01 mm, and physical clay consists of particles smaller than 0.01 mm. Together with the soil skeleton (particles larger than 1 mm), they form the mechanical composition of the soil and its fertility. Their content in the horizon (Elh) was 63.73 and 36.27%, respectively, with a salt pH of 3.6. The sum of metabolic acids was 6.45, the hydrolytic acidity was 8.6, and the soil absorption capacity (SAC) was 15.05 mg-Eq/100 g of soil. The degree of saturation with bases was 43%, and the presence of humus was 0.50%. Examining the horizon (I), at a depth of 60-70 cm, a red-brown, prismatic, dense, transitional gradual soil layer was found. Its humidity was 2.88%. Physical sand was 54.63%, and physical clay was 48.37%, the salt pH was 3.6, and humus was 0.46%.

On the territory of the permanent nursery in compartment 92, a soil section was taken at a depth of 142 cm, that is, to the depth of the soil-forming rock. Type of growing conditions fresh oak forest (D_2). In the soil section, five genetic horizons were found that differ from each other – HA, Iha, I, Pi, Pk. Horizon thickness, respectively: HA – 25 cm, Iha – 48 cm, I – 90 cm, Pi – 142 cm. Boiling depth is an indicator that characterises the depth at which the soil begins to release carbon dioxide (CO_2) when adding an acid, such as hydrochloric acid (HCl). This phenomenon is associated with the presence of carbonates in the soil. The deeper the boiling layer lies, the deeper the carbonates are. Boiling can be strong, medium, weak, or absent. The depth of boiling in grey forest loam was 142 cm, and the intensity of boiling was estimated as average. Therefore, the boiling depth is not an indicator of CO_2 release when adding acid. CO_2 release when adding HCl indicates the presence of carbonates in the soil and the degree of its liming, and not the depth at which the soil "boils".

Analysing the physical and chemical parameters of grey forest soils formed on loessial and forest-like loams, in the variant of grey forest loamy soil, it was clear that in the HA horizon was in the soil layer of 0-28 cm, the humidity was 1.88%. In the soil layer at a depth of 35-45 cm in the Iha horizon, the moisture content was 2.24%, and at a depth of 65-75 cm, the soil moisture content was the highest – 4.27%. In the lower horizons of Pi and Pk at depths of 110-120 cm and 142-152 cm, humidity decreased to 2.04 and 1.31%, respectively. It is appropriate to note that the depth of distribution of plant roots can be traced up to 30 cm. The sum of particles >0.01 mm and <0.01 mm was related to the granulometric composition of the soil, since this is the particle size distribution. This distribution affects the properties of the soil, in particular, water permeability, breathability, the ability to retain moisture and nutrients. In the genetic HA horizon at a depth of 0-28 cm, 66.60% of physical sand was found, and its content decreased with depth from 66.60% in the HA horizon to 51.15% in the Pk horizon at a depth of 142-152 cm. The content of physical clay had the opposite trend: if in the soil layer at a depth of 0-28 cm it was 33.40%, then at a depth of 142-152 cm it increased to 48.85%.

At a depth of 0-28 cm, the content of physical clay was 33.40%, while at a depth of 142-152 cm it increased to 48.85%. In the grey forest loamy variant, the salt pH in the HA horizon at a depth of 0-28 cm was 4.3. In the soil layer of 35-45 cm, the salt pH decreased by 0.4 units and was equal to 3.9. Starting from the iluvial (I) horizon, where the salt pH was 4.0, to the genetic horizon at a depth of 142-152 cm (Pk), this indicator increased to 8.1. The sum of exchange bases (SEB) is the total amount of calcium cations (Ca^{2+}), magnesium (Mg^{2+}) and hydrogen (H^{+}), absorbed by the soil absorption complex. It is measured in milliequivalents per 100 g of soil. This indicator characterises the ability of the soil to retain cations, which is important for plant nutrition and maintaining fertility. At the experimental site, the sum of exchange bases ranged from 7.51 mg-Eq/100 g in the humus-alluvial horizon to 10.23 mg-Eq/100 g in the low-humus and low-alluvial horizons. The hydrolytic acidity of the soil reflects the ability to release hydrogen and aluminium ions when interacting with a solution of hydrolytically alkaline salt. It is an indicator of the potential acidity of the soil and includes active (hydrogen ions in the soil solution) and exchange (hydrogen and aluminium, which are replaced by salt cations). In the study variant, this indicator was 4.0 mg-Eq/100 g at a depth of 0-28 cm and 4.6 mg-Eq/100 g at a depth of 35-45 cm. The soil absorption capacity (SAC) is the total amount of cations that the soil can retain and Exchange. It is measured in milliequivalents per 100 g of soil (mg-Eq/100 g) and characterises the ability of the soil to accumulate nutrients (K^+, Mg^{2+}, Ca^{2+}, etc.), which determines its fertility. In the HA horizon at a depth of 0-28 cm, the SAC was 11.51 mg-Eq/100 g, while in the Iha horizon at a depth of 35-45 cm – 14.88 mg-Eq/100 g.

The degree of base saturation in both genetic horizons at a depth of up to 45 cm had no significant differences and was in the range of 65-69%. The degree of base saturation, also known as base saturation, is an indicator that characterises the content of exchange bases in the soil, expressed as a percentage of the total cationic exchange capacity (CEC). It shows how much CEC is occupied by the main cations (calcium, magnesium, potassium, sodium, etc.). Humus is a dark organic substance that is formed in the soil during the breakdown of plant and animal residues, in particular, under the action of anaerobic organisms. Humus contains a significant amount of nutrients, the most important of which is nitrogen. The humus content in grey forest loamy soil varied along genetic horizons from 1.22 to 0.47%. Thus, 1.22% of humus was found in the HA horizon at a depth of 0-28 cm, in the Iha horizon its content was 0.71%, and in the I – 0.61%. The lowest rate – 0.47% – was recorded in the transition to the rock, Pi horizon at a depth of 110-120 cm. This is conditioned by the fact that humus penetrates into the lower horizons mainly due to the movement of dissolved organic substances (humic acids, etc.) together with ground water. A certain role is also played by the mechanical transfer of small fractions of humus as a result of the activity of soil organisms and soil formation processes.

The spread of humus to the lower genetic horizons of the soil section is explained by the processes of dissolution and movement, mechanical transfer, soil formation, and soil structure and climatic conditions. Thus, in the process of dissolution and movement, humic acids, which are an important component of humus, dissolve well in water and, together with filtration flows, penetrate into the lower layers, enriching them with organic matter. Mechanical transfer is associated with the activity of soil organisms – insects, worms, fungi, etc., which, feeding on organic residues, are able to move humus particles to different depths. Soil formation processes also occur in the lower horizons, where humification is noted – the formation of humus from plant and animal residues that get there as a result of various processes. This leads to the accumulation of humus even in deeper layers, although in much smaller amounts than in the upper horizons. The soil structure also determines the conditions for humus penetration. In soils with a well-developed structure, the presence of pores and channels, water and dissolved substances penetrate deeper more easily, which contributes to the movement of humus. Climatic conditions also play an important role, since humidity and temperature affect the rate of dissolution and transportation of humus substances. In areas with high rainfall and warm climates, humus can penetrate to greater depths than in arid or cold regions. Thus, as a result of these processes, humus gradually accumulates at different levels of the soil, affecting its fertility and properties.

Gross nitrogen is the total amount of nitrogen contained in the soil. Determining gross nitrogen is important for assessing soil fertility. Gross nitrogen in the soil includes various forms of nitrogen, such as organic nitrogen, ammonium nitrogen (NH4+), and nitrate nitrogen (No3-). In the experimental section, the gross nitrogen content was most prevalent in the HA genetic horizon at a depth of 0-28 cm 0.11%, while in the soil layer at a depth of 35-45 cm in the Iha horizon, the content was 0.06%, that is, 1.83 times less. The CN content in the soil refers to the ratio of carbon (C) to nitrogen (N), which is an important indicator of soil fertility and the processes that occur in it. This ratio affects the rate of decomposition of organic matter, the availability of nutrients for plants, and the overall condition of soil biota. CN content in the HA genetic horizon at a depth of 0-28 cm was 6 units, and in the next horizon (Iha) at a depth of 35-45 cm, its content increased to 7 units, or by 16.68%.

The interaction of carbon and nitrogen is extremely important for understanding the decomposition potential of plant residues, and therefore for developing a fertiliser system, monitoring composting conditions, etc. The higher the value of C:N, the slower the decomposition process is. Free nitrogen is actively attracted by microorganisms from the soil, and if it is not enough, there may be a shortage of this element for plant nutrition for the next season. The optimal C:N ratio is 20-30:1. The total nitrogen content in the arable layer of different soil types is low: it varies from 0.05 to 0.3% and directly depends on the presence of organic substances in them. Its reserves in the arable soil layer range from 2.4 to 8.7 t/ha. Studies conducted based on a large array of data have shown that there is a direct relationship (correlation coefficient $r > 0.9$) between the content of total nitrogen and humus in soils. Soil residues of the non-chernozem zone contain the following amounts of gross nitrogen: sandy loam 0.05-0.07%, loam 0.10-0.20%, clay 0.10-0.23%, peat 0.5-1%. Presence of phosphorus P_2O_5 in the ground section is relatively low and at a depth of 0-28 cm is 3.75 mg per 100 g of soil. With depth, its content increased at a depth of 35-45 cm it was 5.0 mg per 100 g of soil. Phosphorus is one of the main elements of nutrition for plants, along with nitrogen and potassium. It plays an important role in the development of the root system, promotes flowering and fruiting, and increases the resistance of plants to diseases and pests. A lack of phosphorus can lead to slower growth, discoloration of leaves, and poor crop quality.

Potassium is an important element of nutrition for plants, playing a key role in many physiological processes, in particular, in regulating water balance, photosynthesis, nutrient transport and increasing resistance to diseases and stressful conditions. A lack of potassium can lead to slower plant growth, reduced yields, poor product quality, and increased sensitivity to diseases and stressful conditions. Visually, the lack of potassium can be determined by changes in the colour of the leaves (yellowing, browning, burns at the edges), and by wrinkling and twisting of the leaves. Potassium content (K_2O) in different soils varies from 0.5 to 3% and depends on the mechanical composition. More potassium is contained in the clay fraction of the soil. Therefore, heavy clay and loamy soils are richer in potassium (2-3%) than sandy and sandy-loamy (1.5-2%). Peaty soils are very poor in potassium (0.03-0.05%). Most loamy soils contain 2-2.5% potassium, which is significantly more than nitrogen and phosphorus. Analysing the potassium content (K_2O) in grey forest loamy soil in a nursery up to a depth of 45 cm, the potassium content in both genetic layers of the soil was found at a volume of 10.5 mg per 100 g of soil.

Hydrolysed nitrogen, in particular alkaline hydrolysed nitrogen according to the Cornfield method, is an indicator that characterises the content of nitrogen potentially available to plants in the soil. It indicates the amount of nitrogen that can be released from soil organic compounds by alkaline hydrolysis and, therefore, can be used by plants. This indicator is not an absolute measure of the available nitrogen content, since plants can absorb nitrogen in various forms, but it does give an idea of how much nitrogen can be released and used over a certain period of time. Nitrogen is a key element of nutrition for plants, necessary for the synthesis of proteins, chlorophyll, and other important compounds. The hydrolysed nitrogen index characterises the supply of nitrogen to plants during the growing season. This is a supply of nitrogen that will be available to plants in the future. In grey forest loamy soil in a soil section made on a permanent nursery in the humus horizon (HA) at a depth of 0-28 cm, the content of hydrolysed nitrogen was 9.48 mg per 100 g of soil, and at a depth of 35-45 cm, its content decreased to 5.60 mg per 100 g of soil, or 59.07%.

In division 2 of compartment 85, a soil section was established at a permanent nursery in the Husiatyn Forestry to investigate the structure of the soil, its properties, and to determine the boundaries between different types of soils. This section will help to understand how the soil is formed, what layers are present in it, and what processes occur inside, and identify the physical and chemical features of the soil. At the permanent nursery of the Husiatyn Forestry, a soil section was made to a depth of 140 cm, considering that the main mass of roots extends to a depth of 30 cm. The depth of boiling characterises the depth at which the soil begins to release carbon dioxide (CO_2) when hydrochloric acid (HCl) is added, it is detected to a depth of 140 cm. When hydrochloric acid (HCl) is added to the soil, a reaction occurs with carbonates contained in the soil. This reaction releases carbon dioxide (CO_2). This is not related to the boiling point. Measurement of the amount and rate of CO_2 release helps to determine the content of carbonates in the soil, which indicates the degree of liming.

At the nursery, the type of growing conditions – wet oak forests (D_3), therefore, soil humification can be observed – this is a complex biochemical process that occurs in anaerobic conditions (in the absence of oxygen) in the presence of organic substances and with the participation of anaerobic microorganisms, resulting in the restoration of iron-containing compounds in the soil, which manifests itself in a change in soil colour to grey, bluish, or greenish. The strength of genetic horizons along the lower boundary depending on the horizon was found for HA – 26 cm, Iha – 51 cm, I – 100 cm, transitional to the rock, Pi – 140 cm. According to the terrain, the territory of the nursery is located on a plateau. It is a structural plain covered with loess, with developed erosion. Loess is a continental soil-forming mountain sedimentary rock with greyish-yellow, sometimes brown or reddish-brown colour. The thickness of loessial layers ranges from several tens of centimetres to several tens of metres on the watersheds and slopes of ancient valley terraces.

Analysing Table 1, grey forest clay loamy soil that was formed on loessial and loess-like loams, there is a clear distribution of it over genetic horizons, namely: HA, with a thickness of 0-26 cm; Iha, where the sample was taken at a depth of 30-40 cm; I, where the sample was taken at a depth of 65-75 cm, transitional to the rock; Pi, where the sample was taken at a depth of 115-125 cm, and Pk – sample taken at a depth of 150160 cm. Soil moisture in the pit is measured to determine the moisture content in a particular layer of soil that is taken when digging the pit. Humidity affects soil properties such as density, water retention, and nutrient retention. The highest soil moisture was found in the I layer of soil at a depth of 65-75 cm, the content of which was 6.38%, although humidity fluctuations along genetic horizons were in the range of 3.09-6.38%. In the horizons of the transition to rock, Pi (soil layer at a depth of 115-125 cm) and Pk (sample taken at a depth of 150-160 cm), the soil moisture in both pits was identical and amounted to 4.16%. The presence of silt with a fraction <0.001 mm was detected in grey forest clay loamy soil. Silt contains nutrients such as nitrogen, phosphorus, potassium, and organic substances that improve the structure of the soil and increase its fertility. Silt is also a soil booster that improves the water retention capacity of the soil, reduces its acidity and increases the resistance of plants to stressful conditions. In wholesale sections of a permanent nursery, the silt content along genetic horizons was in the range of 14.81-25.05%. The smallest amount of silt (14.81%) was found in the HA horizon at a depth of 0-26 cm, the biggest – 25.05% in the horizon at a depth of 65-75 cm, that is, in the soil layer in which the humidity was highest and amounted to 6.38%.

In the Iha horizon, the silt content at a depth of 30-40 cm was 18.92%, in the transition to rock, Pi horizon (sample taken at a depth of 115-125 cm), and Pk (sample taken at a depth of 150-160 cm), the silt content was 22.88 and 19.42%, respectively, that is, 3.46% less. Physical sand refers to the sum of all particles with a size of 1-0.01 mm, and particles less than 0.01 mm – to physical clay. The solid phase of the soil consists of mineral and organic particles of different sizes and different chemical compositions. The sum of particles larger than 0.01 mm in the soil refers to the granulometric composition of the soil. This indicator determines the content of particles of different sizes in the soil (sand, loam, clay) and is of great importance for its properties.

In the soil section, the content of physical sand was highest in the HA layer of soil with a thickness of 0-26 cm and was 68.7%. According to the genetic horizons of the Iha soil layer, where the sample was taken at a depth of 30-40 cm and in the I soil layer at a depth of 65-75 cm, its content decreased to 63.3 and 54.4%, respectively, compared to the HA soil layer. In the transition to the rock, Pi horizon (sample taken at a depth of 115-125 cm) and Pk (sample taken at a depth of 150-160 cm), the content of physical sand was the same and amounted to 57.1 and 57.0%, respectively.

The sum of soil particles less than 0.01 mm in size in the soil refers to physical clay. This indicator is an important characteristic of the granulometric composition of the soil and affects its properties, such as water permeability, breathability, ability to retain water and nutrients. The physical clay content affects the soil's ability to retain water and nutrients, and its workability. For example, soils with high clay content (clay soils) retain water well, but can be difficult to cultivate, while soils with low clay content (sandy soils) allow water to pass through well, but are less fertile. Clay particles (less than 0.005 mm, but in the context of the question, most of them are particles of 0.01 mm or more) compact the soil, make it heavier, less permeable to air and water. Analysing the data obtained from the section on the content of physical clay, it should be noted that the opposite trend is observed in comparison with the content of physical sand. The lowest content of physical clay of 31.26% was found in the HA soil layer at a depth of 0-26 cm. In the following soil layers – Iha and I, in samples taken at a depth of 30-40 and 65-75 cm, respectively, an increase in the content can be traced up to 45.53%. It was the highest in the I layer of soil. In the horizon transitional to the Pi rock, (sample taken at a depth of 115-125 cm) and Pk (sample taken at a depth of 150-160 cm), the physical clay content had similar values of 42.82 and 42.95%, respectively.

Diagnosing the state of the soil through salt pH, its value ranges from 4.0 to 8.0. Considering the genetic horizons, in HA, the horizon in the soil layer was 026 cm pH of 4.1 was detected; in the Iha horizon, where the sample was taken at a depth of 30-40 cm, pH was 4.5; in I, (sample taken at a depth of 65-75 cm) – pH 4.0, transitional to the rock; Pi, (sample taken at a depth of 115-125 cm) – pH 4.6, that is, for all genetic horizons to a depth of 0-125 cm of soil was considered already acidic or even very acidic. But in the soil-forming (parent) rock, where the sample is taken at a depth of 150-160 cm salt pH is 8.0 units, which indicates alkalinised soil. This is conditioned by the specifics of the chemical interaction between soil ions and salt solution. This analysis allows seeing more deeply the potential acidity and show how much the soil can neutralise it.

Analysing the sum of exchange bases, hydrolytic acidity, and SAC, their content can be traced to a depth of 75 cm covering three genetic horizons, namely: HA horizon to a depth of 0-26 cm, where the sum of the exchange bases was 7.26 mg-Eq/100 g of soil; almost the same indicator of the sum of exchange bases was 7.30 mg-Eq/100 g of soil was found in the Iha soil layer, where the sample was taken at a depth of 30-40 cm. However, in the soil layer at a depth of 6575 cm of I horizon, the sum of exchange bases increased by 1.82 times and amounted to 13.31 mg-Eq/100 g of soil. Hydrolytic acidity was highest in the HA horizon at a depth of 026 cm was 5.4 mg-Eq/100 g of soil. With the depth of the horizons in the soil layer of the Iha horizon, its content decreased to 3.9 mg-Eq/100 g of soil, and in the I horizon at a depth of 6575 cm, its content increased by 1.21 times and reached 4.7 mg-Eq/100 g of soil.

Soil absorption capacity (SAC) characterises the soil's ability to retain nutrients such as potassium (K), magnesium (Mg), calcium (Ca), etc., and determines soil fertility. Its content in the HA horizon at a depth of 028 cm was 12.66 mg-Eq/100 g of soil, and in the Iha horizon at a depth of 35-45 cm – 11.2 mg-Eq/100 g of soil. Soil absorption capacity at a depth of 65-75 cm in the I layer of soil was 18.01 mg-Eq/100 g of soil, which was 1.42 times more than HA and 1.61 times more than Iha horizons. The degree of base saturation in both genetic horizons at a depth of up to 45 cm does not have any special differences, although it is located with a difference of 8.0%, respectively, with genetic horizons of 57 and 65%. I, at a depth of 65-75 cm, the content was 74%. The degree of base saturation, also known as base saturation, is an indicator that characterises the content of exchange bases in the soil, expressed as a percentage of the total cationic exchange capacity (CEC). It shows how much CEC is occupied by the main cations (calcium, magnesium, potassium, sodium, etc.). Humus content in the HA soil layer at a depth of 0-26 cm was 2.01%, in the Iha horizon, at a depth of 30-40 cm decreased to 0.62%. A decrease in the humus content can be traced in the I layer of the soil, the sample was taken at a depth of 65-75 cm to 0.55%, and in the Pi layer of the soil transitional to the rock at a depth of 115-125 cm, where its content was 0.41%. Gross nitrogen in the HA horizon was 0.18%, and in the Iha, a soil layer at a depth of 30-40 cm, its content decreased to 0.04%, or 4.5 times. The interaction of carbon and nitrogen C:N shows that the higher the value of C:N, the slower the decomposition process of plant residues takes place.

Presence of phosphorus P_2O_5 in the ground section it is relatively low and at a depth of 0-28 cm is 10.00 mg per 100 g of soil. With depth, its content decreased twice and at a depth of 30-40 cm it was 5.0 mg per 100 g of soil. Phosphorus is one of the main elements of nutrition for plants, along with nitrogen and potassium. A lack of phosphorus can lead to slower growth, discolouration of leaves, and poor crop quality. Potassium is an important element of nutrition for plants. A lack of potassium can lead to slower plant growth, reduced yields, poor product quality, and increased sensitivity to diseases and stressful conditions. Analysing the potassium content (K_2O) in grey forest loamy soil in a nursery up to a depth of 26 cm, the potassium content was found in a volume of 10.5 mg per 100 g of soil, but at a depth of 30-40 cm of its content decreased and reached 8.4 mg per 100 g of soil. Hydrolysed nitrogen characterises the content of nitrogen potentially available to plants in the soil. It indicates the amount of nitrogen that can be used by plants. The hydrolysed nitrogen index characterises the supply of nitrogen to plants during the growing season. This is a supply of nitrogen that will be available to plants in the future. In grey forest gleyed loamy soil in a soil section made on a permanent nursery in the HA horizon at a depth of 0-28 cm, the content of hydrolysed nitrogen was 11.48 mg per 100 g of soil, and at a depth of 3040 cm, its content decreased to 9.24 mg per 100 g of soil, or 2.24%.

The division 2 of compartment 22 contains arable land, where the section was made to a depth of 130 cm. In the soil section, the HA horizon with a thickness of 026 cm was highlighted; Iha horizon, where the sample was taken at a depth of 34-45 cm, and the total thickness of this horizon was 56 cm, and the I horizon was 100 cm thick, where the sample was taken at a depth of 65-75 cm, and Pk, the thickness of which was 127 cm, and the sample was taken at a depth of 125-130 cm. The depth of the parent rock is 127 cm, the depth of distribution of the main mass of roots is 26 cm, the type of growing conditions is fresh oak forest (D_2). The depth of boiling characterises the depth at which the soil begins to release carbon dioxide (CO_2) when hydrochloric acid (HCl) is added, It is detected to a depth of 127 cm. South-western relief exposition, steepness 7°, even shape.

Studying soil moisture by genetic horizons, it should be noted that it fluctuates in the range from 2.56 to 3.84%, that is, with a difference of 1.28%, which can be considered insignificant. The greatest humidity was found in the illuvial horizon at a depth of 65-75 cm – 3.84%. 21.32-

31.82% of silt was found in the soil. The highest content of 31.82% was found in the iluvial (I) horizon at a depth of 65-75 cm. The content of physical sand (sum of particles >0.01 mm) had a slight deviation and was located in the HA horizon in a volume of 57.0%, in Iha and Pk, respectively, 57.3 and 57.7%, while in the illuvial layer of soil its content was 50.08%, which was 6.927.62% less than in other horizons. Studying the content of physical clay (the sum of particles <0.01 mm), the reverse pattern can be traced along the genetic horizons. The highest content of physical clay of 49.92% was found in the I horizon. In other genetic horizons, its content was 43.00%, 42.66%, and 42.25%, respectively, where there is an insignificant difference of 0.75%.

Salt pH is an indicator of acidity determined in a weak saline solution. It is used to clarify the acidity of slightly acidic soils (approximately pH 6.5-7.4). During the research, the pH was determined to be within 5.8-6.5. The highest pH value was found in the HA layer of soil – 6.5. Salt pH values of 5.8 and 5.9 were found in the Iha horizon, where the sample was taken at a depth of 30-40 cm and in the I horizon, where the sample was taken at a depth of 65-75 cm. Reduction of acidity by 0.7 and 0.6 units. Reduction of soil acidity by 0.7-0.6 units on the salt solution pH scale means that the soil has become less acidic. The pH scale used to measure soil acidity is logarithmic, so the change is 0.7-0.6 units indicates a relatively moderate decrease in acidity. This means that the amount of hydrogen (H+) ions in the soil solution has decreased, which can affect the availability of nutrients for plants. Changes in pH can affect the solubility and availability of nutrients in the soil. For example, as acidity decreases (pH increases), elements such as phosphorus, molybdenum, and calcium may become more readily available to plants, while others such as iron, manganese, and zinc may become less readily available.

The sum of exchange bases, hydrolytic acidity, and cationic exchange capacity (CEC) are important indicators of soil fertility. They characterise the ability of the soil to retain and exchange ions, and its acid-base properties. The sum of the exchange bases determines the number of cations (positively charged ions) that the soil can hold on its surface. It includes basic cations such as calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^{+}), sodium (Na^{+}), etc. In the soil section, the sum of exchange bases ranged from 15.81 mg-Eq/100 g of soil in the HA horizon up to 20.33 mg-Eq/100 g of soil in the I horizon, where the sample was taken at a depth of 65-75 cm. The nominal amount of exchange bases is in the range of 10-22 mg-Eq/100 g of soil. Thus, the high sum of exchange bases in the soil section indicates a good supply of nutrients to the soil and its ability to neutralise acidity. Hydrolytic acidity shows the amount of hydrogen (H^{+}) and aluminium (Al^{3+}), which can be released from the soil and exchanged for other ions. It is measured when the soil is treated with alkaline solutions that help to displace these ions.

In the soil section, hydrolytic acidity depending on the genetic horizon was found in HA horizon in volume 1.1, in Iha horizon – 1.6, and I horizon – 1.3 mg-Eq/100 g of soil. Hydrolytic acidity of the soil 1.1-1.6 mg-Eq/100 g of soil, indicates that the soil contains a significant amount of exchange hydrogen and aluminium ions, which can be released and affect the acidity of the medium. This value indicates moderate soil acidity, which can affect the availability of nutrients for plants and will require measures to regulate the acidity if necessary.

Soil absorption capacity of cations (SAC) is a measure of the soil's ability to retain positively charged ions such as calcium, magnesium, potassium, and sodium. The higher the SAC, the more nutrients the soil can retain for plants (Tyhonenko, 2005). In grey forest gleyed loamy soil of arable land capacity of absorption capacity of soil cations (SAC) in the HA soil layer at a depth of 226 cm was 16.91 mg-Eq/100 g of soil, in the Iha horizon at a depth of 30-40 cm – 18.26 mg-Eq/100 g of soil, and the I horizon at a depth of 65-75 cm contained 21.63 mg-Eq/100 g of soil. Therefore, soil with an absorption capacity of 16.91-21.63 mg-Eq/100 g has an average level of ability to retain nutrients and provide fertility. In a genetic section made on arable land, the degree of base saturation was found in the HA layer of soil at a depth of 226 cm in a volume of 57%, the Iha horizon at a depth of 30-40 cm contained 65%, and the I horizon at a depth of 65-75 cm contained 74%, which was 17% more or 1.3 times compared to the humus-alluvial (HA) horizon. Notably, soils saturated with bases are considered optimal in the range of 65-75%. In the grey forest gleyed loamy soil of ploughed lands, the humus content ranged from 0.55 to 1.88%. Grey forest soils are formed in conditions of sufficient moisture under broad-leaved forests. They are characterised by a low humus content, which makes them less fertile compared to chernozems. The humus content may vary depending on the specific subtype of grey forest soil, such as light grey, grey, or dark grey (Poznyak, 2010).

Considering these data, the range from 0.55 to 1.88% for grey forest clay-loamy soils of arable land was justified. The gross nitrogen content in the HA soil layer was 0.13%, and in subsequent horizons at a depth of 34-75 cm its content was 0.04%, which is 3.25 times less than in the HA soil layer. In the soil, most of the gross nitrogen (93-97%) is part of humus, and the rest is in the form of mineral compounds that are available to plants. The gross nitrogen content in the soil can vary widely, but usually ranges from 5.0 to 6.8% of the humus content. Thus, the concept of "gross nitrogen" in the context of soil and plants indicates the total amount of nitrogen, including both available and inaccessible forms for plants.

The interaction of carbon and nitrogen C:N shows that the higher the value of C:N, the slower the decomposition process of plant residues takes place (Nazarenko *et al.*, 2004). The HA soil layer at a depth of 226 cm revealed the ratio of carbon to nitrogen – 6, in Iha horizon at a depth of 30-40 cm, this ratio was 8. If the C:N ratio is high, it means that the soil has a lot of energy for microorganisms, but the quality or nutritional value of these elements is low. The higher the initial C:N ratio, the longer the decomposition of residues takes. Organic nitrogen is used by microbes to quickly break down nutrient residues and create proteins that are vital for their growth and reproduction. In perfect condition, healthy soil has a C:N ratio of 10:1 to 12:1, which means that the microbial biome is balanced. Content of phosphorus P_2O_5 in the ground section it is relatively low and at a depth of 0-28 cm is 20.00 mg per 100 g of soil. With depth, its content decreased by 2.29 times and at a depth of 30-40 cm it was 8.75 mg per 100 g of soil. Phosphorus is one of the main elements of nutrition for plants, along with nitrogen and potassium. A lack of phosphorus can lead to slower growth, discolouration of leaves, and poor crop quality.

Lack of potassium (K_2O) may lead to slower plant growth, reduced yields, poor product quality, and increased sensitivity to diseases and stressful conditions (Kumar *et al.*, 2023). Analysing the potassium content in grey forest gleyed loamy soil on ploughed lands to a depth of 26 cm, the potassium content was found in the volume of 10.5 mg per 100 g of soil, the same content of 10.5 mg per 100 g of soil at a depth of 34-45 cm. The potassium content in the I horizon increased and reached 14.0 mg per 100 g of soil. Hydrolysed nitrogen characterises the supply of nitrogen to plants during the growing season. In grey forest gleyed loamy soil in a soil section made on a permanent nursery in the HA horizon at a depth of 2-26 cm, the content of hydrolysed nitrogen was 3.64 mg per 100 g of soil, and at a depth of 34-45 cm, its content increased to 5.88 mg per 100 g of soil, or 1.62%. In the I horizon, hydrolysed nitrogen decreased to 3.64 mg per 100 g of soil. The content of alkaline hydrolysed nitrogen reflects the amount of nitrogen that can be used by plants in the near future. The smallest significant difference in all variants of the experiment was within the normal range – 2.01-3.01, which indicates the reliability of our research.

According to H.S. Ivanyuk (2017), who conducted a thorough analysis of soil classifications in Poland and Ukraine, some subtypes of chernozem soils are most similar to grey forest soils in terms of properties. When comparing the results of current research with the work of the above researcher, this statement can be agreed with. Since the presented samples contain a sufficient amount of minerals, which makes the soils of the region suitable for growing various plant species, and in chernozem types. S. Bogdanov *et al.* (2025) analysed how different forest types and treeless areas affect the morphological, chemical, and organic properties of grey forest soils in northeastern Bulgaria. The researchers compared soil sections under different forest types and unordered (treeless) areas, finding a clear dependence of the soil structure on vegetation – the forest causes a deeper humus horizon, and more developed profile characteristics. The data obtained in the current study that the type of forest (tree species) affects the nitrogen content, pH value and C:N ratio in the soil are partially consistent with our conclusions regarding the content of these minerals in the soil. Since the higher the initial ratio of these elements, the longer the decomposition of residues lasts, that is, the soil has a lot of energy for microorganisms. In current studies the HA soil layer at a depth of 226 cm revealed the ratio of carbon to nitrogen – 6, in the Iha horizon at a depth of 30-40 cm, this ratio was 8. This indicates that the soil horizons are not sufficiently provided with these elements. M. Lungu (2015) analysed the evolution of grey forest soils used as arable land after deforestation in the central part of Moldova, in the Codri region. The researcher used the method of comparing grey soils under the forest, grey arable soils used in agriculture for about 100 years, and grey arable soils that had a long period of development under the steppe before being used in agriculture. As a result of agricultural use, the first three horizons of forest soils (AEh, AEh, and BEhtw) were mixed into one. Use in agriculture also led to a decrease in the humus content, a decrease in the intensity of illuvial-alluvial and cambic processes, a decrease in soil acidity, soil compaction, and deterioration of its structural state. In contrast to the research of this researcher, current studies clearly trace the presence of all genetic horizons. It follows that forest soil types are less susceptible to destructive processes and can recover faster.

S. Bogdanov (2014) analysed the effect of forest fires on the composition of texture fractions (sand, dust, clay) in the profile of grey forest soils. According to his research, the intensity of a fire can reduce the proportion of these fractions in the upper horizons due to the burning of organic matter and changes in the aggregate structure. The data obtained are important for understanding long-term changes in soil water and air permeability after fires and for restoring forest biocenoses. The researcher also claims that despite the influence of external factors, the soil texture is one of the most conservative indicators and changes slowly and only under certain circumstances. This is consistent with the results of current research.

Research by O. Havryshko *et al.* (2024) showed that long-term use of arable land plots changes the distribution of sand and clay in the soil profile, leading to compaction, a decrease in the proportion of agricultural groups, and changes in porosity, which affects water-physical properties. The researchers emphasised that even small changes in the particles of physical clay/sand have a significant effect on the ability of the soil to retain water and restore structure after mechanical impact. In addition, it was demonstrated that key elements (C, N, organic matter) are closely correlated with each other and are distributed unevenly across all soil horizons, as in current studies. I. Kirilov *et al.* (2022) found that during the processes of podzolisation of the upper horizons, the content of the pulverised fraction below the humus horizon increases. In contrast to the results of the above researchers, current studies show a uniform distribution of particles of different fractions over all soil horizons.

S. Gaidar *et al.* (2024) investigated easily hydrolysed nitrogen and total nitrogen in cultivated grey forest soils. Similar to current studies, these researchers concluded that high soil acidity can reduce the level of this element in the upper genetic horizons. This means that it needs to be regulated using mineral fertilisers with the appropriate ratio of elements. N.M. Pavliuk & V.G. Haskevych (2011) described in detail the physical and chemical properties of Opillia soils in a monograph. The researchers state that the studied soils in Opillia are characterised by a very low content of absorbed cations. The soil-absorbing complex of these soils is dominated by calcium and magnesium cations. In the direction from northwest to southeast, the content of calcium cations decreases in the humus horizons of light grey forest soils and the content of magnesium cations increases. In contrast to their results, soils in the region of the current study have a sufficient level of cations and are characterised by a normal distribution of absorbed bases over genetic horizons.

Summarising the results of the conducted research, it can be noted that the grey forest soils of the Husiatyn Forestry are marked by a clear differentiation by genetic horizons, significant fluctuations in physico-chemical parameters, and a significant dependence on the conditions of use (arable land, nurseries, forest crops). The established differences in humus content, degree of base saturation, acidity, granulometric composition and other properties confirm the multifactorial nature of their transformation under the influence of natural and anthropogenic factors. The data obtained are consistent with the conclusions of previous researchers, but simultaneously emphasise the specifics of soil processes in the region under study, which is of great practical importance for the development of optimal agricultural technologies in nurseries and improving the efficiency of growing planting material.

Conclusions

The study of the properties of grey forest soils showed significant differences in their agrochemical state depending on the type. Light grey soils are characterised by a poor humus profile and low base saturation, which leads to their weak fertility. In contrast, grey loamy and gleyed soils have a higher capacity of the absorption complex, higher humus content and better indicators of agrochemical supply. According to the granulometric composition, all variants belong to loams with a physical clay content of 40-50%. The upper horizons contain more silt and fine particles, which reduces their water permeability. The reaction of the soil solution in the upper layers was acidic (pH 3.6-6.5), which limits the availability of nutrients for plants, while in the lower horizons the indicators increase to 8.0-8.1, which indicates the presence of a carbonate horizon and confirms the genetic features of grey forest soils on loess-like rocks. The humus content in light grey soils was only 0.5-1.2%, while in grey loamy and gleyed soils it was higher (1.2-2.0%), especially in variants under arable crops (1.8-2.0%). Total nitrogen in the upper horizons was in the range of 0.1-0.18%, with a C:N ratio of about 8, which indicates rapid mineralisation of organic matter and insufficient reserves of stable humus compounds. Phosphorus supply ranges from very low (3.75-10 mg/100 g) to high (20 mg/100 g in arable land), and the potassium content is mostly stable (10-14 mg/100 g), although sometimes it decreases to 5-6 mg/100 g. Hydrolysed nitrogen reserves are medium or low (3.6-11.5 mg/100 g), which further limits the fertility of these soils.

Further research should be aimed at detailed monitoring of changes in the humus profile and macronutrient availability in various agrotechnical systems. It is also advisable to investigate the stability of organic matter and ways of its accumulation in light grey soils with the lowest humus content, and search for optimal land reclamation and agrochemical measures to increase their fertility.

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None.

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Вміст поживних речовин у сірих лісових ґрунтах Гусятинського лісництва

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Анотація. Метою дослідження було з'ясування фізико-хімічних особливостей різних типів лісових ґрунтів та оцінка їх агрохімічного стану на постійних розсадниках, орних землях та 30-річних культурах дуба звичайного в умовах Гусятинського лісництва Чортківського надлісництва. Було застосовано ґрунтово-агрохімічні методи аналізу, що включали визначення фракційного та механічного складу, вмісту гумусу, насиченості основами та ємності поглинального комплексу. Порівняння показників здійснювали між світло-сірими, сіро-суглинистими та глеюватими ґрунтами, що дало змогу охарактеризувати їх продуктивність та агрохімічний потенціал. Встановлено, що у більшості ґрунтів верхні горизонти кислі (pH 3,6-5,0), що негативно впливає на доступність поживних речовин, у світло-сірих ґрунтах вміст гумусу низький (0,5-1,2 % у верхніх горизонтах). У сірих суглинистих і глеюватих ґрунтах гумусу більше (1,2-2,0 %), особливо в орних варіантах (1,8-2,0 %). Загальний азот у верхніх горизонтах становив 0,1-0,18 %, що є досить низьким. Співвідношення C:N було близьке до 8, що свідчить про швидку мінералізацію органічної речовини. Деякі ділянки добре забезпечені P_2O_5 (20 мг/100 г), але є ґрунти з дефіцитом (<10). Забезпеченість калієм більш стабільна, але в орних горизонтах можливе виснаження. Фосфор (P_2O_5): коливався від дуже низьких значень (3,75-10 мг/100 г) до підвищених (20 мг/100 г у орних землях). Калій (K_2O): тримався на рівні 10-14 мг/100 г, але в окремих випадках знижується до 5-6 мг/100 г (погіршення забезпеченості). Гідролізований азот: показники 3,6-11,5 мг/100 г, що вказує на середню або низьку забезпеченість азотом. Результати дослідження фракційного та механічного складу ґрунту в умовах дібров на прикладі Гусятинського лісництва мають вагоме практичне значення для розроблення рекомендацій, щодо особливостей закладання лісових культур у даному регіоні та захисту ґрунту від ерозійних процесів

Ключові слова: генетичні горизонти; фракції; вологість; ємність; поживні речовини