УДК 631*4:630*114:630*187

ESTIMATION OF FOREST SOILS PROPERTIES ON WATER-GLACIAL DEPOSITS IN DIFFERENT TYPES OF FOREST CONDITIONS

V. Krasnov[1], O. Zborovska[2], S. Sukhovetska[1], V. Landin[3], V. Zakharchuk[3]

[1] Житомирський державний технологічний університет
[2] Поліський філіал Українського науково-дослідного інституту лісового господарства і агролісомеліорації ім. Г.М. Висоцького
[3] Інститут агроекології і природокористування НААН

Наведено результати досліджень гранулометричного складу та вмісту поживних елементів генетичних горизонтів дерново-підзолистих ґрунтів, сформованих на водно-льодовикових відкладах, у різних типах лісорослинних умов. Дослідження проводили у свіжих борах і суборах під насадженнями сосни звичайної різного віку. Виявлено, що основна кількість коренів сосни звичайної формується до глибини 60–80 см. Встановлено, що більший уміст нітрогену, калію та гумусу накопичено у свіжих суборах порівняно зі свіжими борами. Висловлено припущення, що лісорослинний потенціал піщаних ґрунтів з часом (у процесі наростання біомаси із збільшенням віку лісового насадження) дещо знижується.

Ключові слова: *лісові ґрунти, водно-льодовикові відклади, соснові лісові культури, родючість ґрунту, дерново-підзолисті ґрунти.*

Forest soil cover is in direct dependence on soil-forming and parent rocks. The region of Polissia (according to Tutkovsky) can be divided into three landscapes: outwash, moraine and end-moraine landscapes. «Outwash» landscape was formed by melting glaciers whose powerful streams deposited sand in the direction of their course. In such a way, sandy plains were formed. However, different velocity of streams flow formed sands with different granulometric composition [1].

Not numerous forest-typological researches (1972–2007) allowed defining the main quantitative parameters in the system of «soil- undersoil» [2–7]. It should be noted, that there were not enough scientific studies of the main characteristics of forest soils in certain regions. Research data on the study of sandy soils formed on fluvioglacial deposits in the most typical forest conditions of Zhytomyr Polissia are given in the paper.

MATERIALS AND METHODS

The research goal is to define peculiarities of sandy soils formed on fluvioglacial deposits in the most typical forest conditions. Research was conducted in artificial stand of SE «Luhyny FE» on the territory with dominating outwash landscapes.

Sample plots were laid out in forest stands which are homogeneous on their taxation characteristics. Using the phyto-indication analysis the type of forest conditions was identified. Two sample plots were laid out to gain the objectives of the research: 1st sample plot – laid out in fresh bory with plantations aged 12–100 years old (No. 14–18); 2nd sample plot – laid out in fresh subory (No. 20–24) with plantations aged 14–100 years old (Table 1).

The fertilty was assessed by Soil Index System which includes fundamental soil characteristics (granulometric composition, exchange and actual acidity, NPK content, humus) [8–10].

Table 1

Taxation characteristics of scots pine culture on sample plots

No.	Block	Composition of plantation	Age, years	Average height, m	Average diameter, cm	Growth class	Reserve at the density 1.0, $m^3 \cdot ha^{-1}$
Fresh bory							
15	19	9Scots pine 1Silver birch	23	6.2±0.28	6.2±0.43	III	78
16	18	9Scots pine 1Silver birch	44	12.9±0.38	13.7±0.68	III	234
17	41	10 Silver birch	64	18.8±0.29	19.3±0.64	II	423
18	18	10 Silver birch	100	20.1±0.31	29.5±1.20	III	328
Fresh subory							
21	30	10 Silver birch	23	9.7±0.20	12.3±0.61	I	165
22	34	9Scots pine 1Silver birch	44	15.1±0.57	17.7±0.76	II	327
23	52	10 Silver birch	63	22.3±0.51	23.6±1.03	I	521
24	36	10 Silver birch	100	24.7±0.36	31.2±1.04	II	568

RESULTS AND DISCUSSION

According to the phyto-indication analysis, it was determined that oligotrophs and oligomesotrophs dominate on sample plots No. 14–18 in grassy and shrubby layer; xeromesophytes and mesophytes dominate here to suit water requirements. Thus, fresh bory (A_2) are identified on these sample plots. On sample plots (SP) No. 20–24, prevailing majority of grassy species are the representatives of oligomesotrophs and mesotrophs; such ecological groups as xeromesophytes and mesophytes dominate here to suit water requirements. Maximum quantity of plan species growing here are the indicators of fresh conditions. Thereby, fresh subory (B_2) are the edatope of these sample plots.

On the territory of SE «Luhyny FE», glacial deposits are represented by loose clay sands and loamy sands. Soils on sample plots are identified as soddy slightly–and soddy medium-podzolic soils. According to the level of acidity, soils can be classified as sour soils (pH = 4.2–5.9 in fresh bory; pH = 4.1–5.2 in fresh subory). Fresh bory are characterized by soddy slightly (medium)-podzolic fixed sandy soils on fluvioglacial deposits. Forest litter of 2–10 cm thick is formed on these deposits. Forest litter consists of scots pine needle-foliage and its abscission, green moss and grassy vegetation. The thickness of humus horizon is of 12.00±2.4 cm. The major portion of roots occurs in soil layer down to 60 cm.

Soils of fresh subory are represented by soddy medium-podzolic fixed sandy soils formed on fluvioglacial deposits. The thickness of the forest litter is the same as in fresh bory (2–10 cm). The density of humus-eluvial horizon is of 5.67±1.4cm. Root-containing layer is of 0 — 80 cm thick.

In fresh bory soils, the content of sandy fractions is about 76.0–92.5 %; the content of pulverescent fractions is about 22,7 %, and the content of slit fractions is about 6.1 %. The content of physical clay is 3.2–11.8 %. Both in fresh subory and fresh bory, soil become heavier deep in the profile. It is connected with a high content of slit particles and, as the result, with the content of physical clay in humus horizons which is about 7.2–10.0 %. Maximum values of this indicator (10.1–11.0 %) were observed in loamy sand horizons.

The level of fertility in these soils is low. Fluvioglacial sandy deposits predominantly consist of quartz and, practically, do not contain fine-dispersed fractions. Sandy particles predominate in the composition of soil on sample plots. Such particles cannot accumulate and retain organic mineral compounds. That is why, fresh bory soils are characterized by low humus level in upper humus-eluvial layer (0.88±0.18 %) with its sharp decrease within the profile. Humus content in soil humus-eluvial layer in fresh subory is about 1.64±0.14 % (Pic. 1).

Obtained research results allow making some generalization:

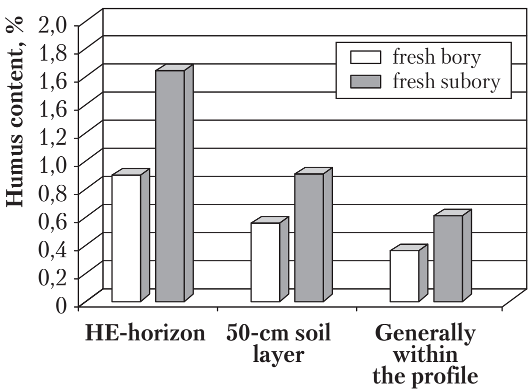
• humus content in fresh bory on fluvioglacial deposits is 42–47 % lower compared to fresh subory;

• humus content decreases by 60–62 % in fresh bory and by 63–66 % in fresh subory from upper soil layer down to the parent rock;

Soddy-podzolic soils on fluvioglacial deposits are also characterized by a low content of fertile elements in all horizons of soil profiles (Pic. 2–4).

The mode of changes of nitrogen and potassium content in separated layers of soil profiles coincides with the changes of humus content:

• nitrogen content in fresh bory on fluvioglacial deposits is 50–55 % lower and potassium content is 37–50 % lower compared to the content of these elements in fresh subory;



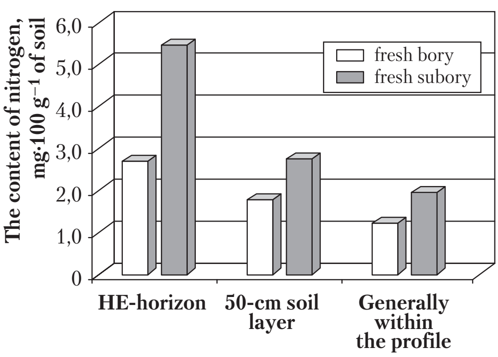
Pic. 1. Humus content in soddy-podzolic soils on fluvioglacial deposits in fresh bory and fresh subory

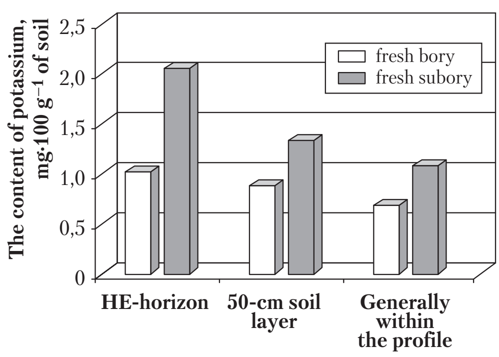
• nitrogen content decreases by 48–55 % in fresh bory and by 63–64 % in fresh subory from upper soil layer down to the parent rock;

• potassium content decreases by 24–32 % in fresh bory and by 35–47 % in fresh subory from upper soil layer down to the parent rock.

Regularities observed in the changes of phosphorus content (Pic. 3) considerably differ from previously observed regularities. Maximum content of this element is observed in 50-cm soil layer; minimum content is observed in humus-eluvial layer.

Thus, the indices of microelements concentration (mg · 100 g^{-1} soil) and humus content (%) in soil are higher in the conditions of fresh subory compared with the same indices in fresh bory. Analyzing the overall profile,



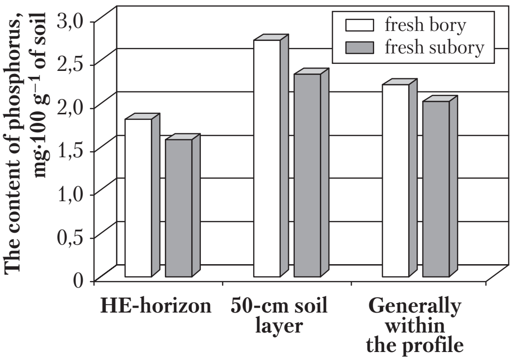


Pic. 2. Nitrogen and potassium content in soddy-podzolic soils on fluvioglacial deposits in fresh bory and fresh subory

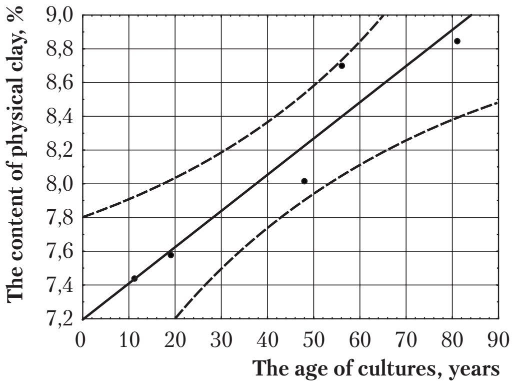
Table 2

Correlation coefficient of soil fertility indices and of the age of pine stands

Soil fertility indices	Root-containing soil layer (50-cm) in types of forest conditions		Humus-eluvial soil layer (HE) in types of forest conditions	
	fresh bory	fresh subory	fresh bory	fresh subory
Sand fraction	0.19	0.08	0.32	0.05
Big-sized dust fraction	–0.25	–0.38	–0.31	–0.07
Physical clay	0.31	**0.96**	0.13	0.38
Humus	–0.67	0.09	**–0.76**	0.06
Nitrogen	–0.67	0.10	**–0.70**	0.03
Phosphorus	–0.26	0.62	0.24	0.36
Potassium	–0.58	0.58		



Pic. 3. Phosphorus content in soddy-podzolic soils on fluvioglacial deposits in fresh bory and fresh subory



Pic. 4. The change of the content of physical clay in root-containing soil layer in fresh subory depending on the age of scots pine culture on fluvioglacial deposits

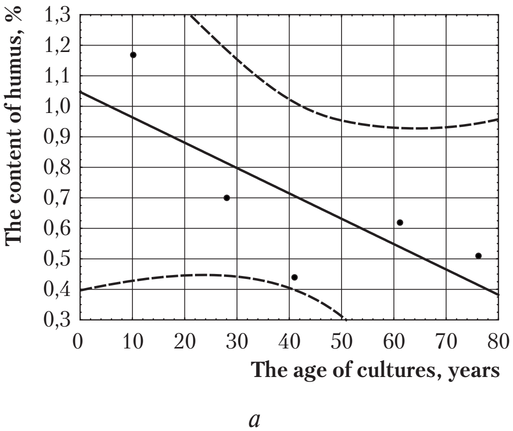
the values obtained for all studied indices (except phosphorus) regularly decrease (by 45–60 % on average).

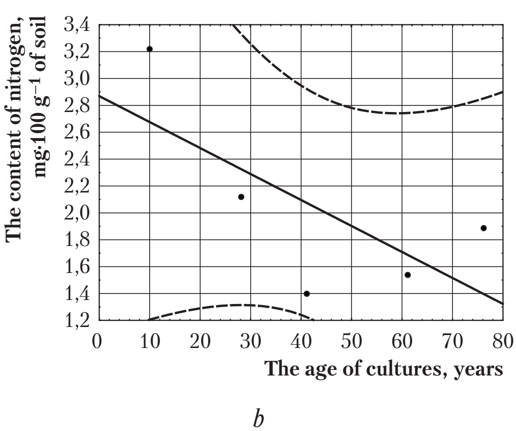
The analysis of soil parameters allowed generalizing of certain characteristics of soil and plantations on studied sample plots. Correlation analysis can be used to detect changes of such indices as the content of sandy fractions, big-sized dust, physical clay, microelements and humus depending on the age of pine cultures in definite trophotops (Table 2). Our research was performed for the soil layer, where the major portion of roots occurs (50-cm), and for the upper fertile layer (HE).

Research results demonstrated that the content of physical clay was the only granulometric index which showed the increase in 50-cm soil layer in the condition of fresh subory. Determination coefficient is — 92.2 % (Pic. 4).

The only index which showed certain connection with the age of plantations in 50-cm soil layer on fluvioglacial deposits was the content of physical clay (phc) (fresh subory): $y_{phc(50)(B_2)} = 7{,}19 + 0.02x$ (where $y_{phc(50)(B_2)}$ — the content of physical clay in 50-cm soil layer in fresh subory; x — the age of scots pine culture).

At the same time, just agrochemical indices change in fresh bory on fluvioglacial deposits depending on the age of stands: the content of humus decreases in 57.8 % of stu-





Pic. 5. The change of HE-horizon in fresh bory in fluvioglacial deposits depending on the age of scots pine cultures: *a* — humus content; *b* — nitrogen content

died samples; the content of nitrogen in 49 % of studied samples.

The equation of the dependencies of the given parameters is the following:

$$y_{g(HE)(A_2)} = 1.05 - 0.008x;$$
$$y_{N(HE)(A_2)} = 2.87 - 0.02x,$$

where $y_{g(HE)(A_2)}$ — humus content in HE-soil horizon in fresh bory; $y_{N(HE)(A_2)}$ — nitrogen content in HE-soil horizon in fresh bory; $y_{P(HE)(A_2)}$ — phosphorus content in in HE-soil horizon in fresh bory; x — the age of scots pine cultures.

Taking into account obtained dependencies, the conclusion can be drawn that forest potential of sandy soils of Zhytomyr Polissia is decreasing with time (with the increase of biomass and the age of forest stands). It can be explained by the rapid pace of nutrients absorption, first of all, by tree species, if to compare with the pace of nutrients release from initial minerals under the action of abiotic and biotic factors. The part of nutrients is kept in the wood and does not return to soil with annual abscission. From our point of view, such assumption needs more detailed study.

CONCLUSIONS

1. Sandy soils on fluvioglacial deposits are characterized by higher acidity, light granulometric composition, insufficient thickness of humus horizon, low humus content and low content of some macroelements. Nitrogen, potassium and humus contents are higher in fresh subory in comparison with fresh bory.

2. Humus and nitrogen contents in HE-horizon, as well as the content of physical clay in root-containing soil layer (50 cm) can be used to analyze forest potential of sandy soils of Zhytomyr Polissia in fresh bory and subory on fluvioglacial deposits.

ЛІТЕРАТУРА

1. Ґрунтознавство з основами геології / О.Ф. Гнатенко, М.В. Капштик, Л.Р. Петренко, С.В. Вітвицький. — К.: Оранта, 2005. — 648 с.
2. *Погребняк П.С.* Лісова екологія і типологія лісів: Вибрані праці / П.С. Погребняк. — К.: Наукова думка, 1993. — 496 с.
3. *Смольянинов И.И.* Резервы элементов почвенного питания растений в равнинных лесах УССР / И.И. Смольянинов, В.А. Сименсон, Е.В. Рябуха // Природные и трудовые ресурсы левобережной Украины и их использование. — Т. 13. — М.: Недра, 1972. — С. 32–38.
4. *Лебедев Е.А.* Миграция азота, кальция, магния и калия по профилю дерново-подзолистых лесных почв / Е.А. Лебедев, В.С. Победов // Почвоведение. — 1984. — № 5. — С. 91–95.
5. *Астапович А.В.* Почвенно-грунтовые условия произрастания сосновых культурфитоценозов мшистого и черничного типов леса Белорусского Полесья / А.В. Астапович // Проблемы

лесоведения и лесоводства. — 2008. — Вып. 68. — С. 5–11.
6. *Распопіна С.П.* Методологічні проблеми оцінки лісопродуктивної здатності земель, що виводяться із сільськогосподарського обігу / С.П. Распопіна // Науковий вісник НУБіП України. — 2010. — Вип. 152. — Ч. 2. — С. 163–170.
7. *Binkley D.* Ecology and management of forest soils / D. Binkley, R. Fisher. — 4th ed. — Oxford: Wiley-Blackwell, 2013. — 347 p.
8. *Яцук І.П.* Аналіз агроекологічного стану ґрунтів Житомирської області за допомогою методики еколого-агрохімічної паспортизації / І.П. Яцук // Землекористування. — 2014. — № 2. — С. 107–110.
9. *Ведмідь М.М.* Оцінка лісорослинного потенціалу земель: Методичний посібник / М.М. Ведмідь, С.П. Распопіна. — К.: ЕКО-інформ, 2010. — 84 с.
10. Почвы. Метод определения обменной кислотности: ГОСТ 26484–85 [Електронний ресурс]. — [Дата введения 01.07.1986]. — Режим доступу: http://www.internet-law.ru/gosts/gost/20253/
11. Методическое пособие по аналитическим работам для агрохимической службы Украины. — Ч. 1. — К., 1989. — 118 с.

REFERENCES

1. Hnatenko, O.F., Kapshtyk, M.V., Petrenko, L.R., Vitvyts'kyy, S.V. (2005). *Gruntoznavstvo z osnovamy heolohiyi [Soil science with the basics of geology].* Kyiv: Oranta [in Ukrainian].
2. Pohrebniak, P.S. (1993). *Lisova ekologiya i typolohiya lisiv: Vybrani pratsi [Forest ecology and typology of forests: selected works].* Kyiv: Naukova dumka [in Ukrainian].
3. Smolianinov, I.I., Simenson, V.A., Ryabukha, E.V. (1972). Rezervy elementov pochvennogo pitaniia rastenii v ravninnykh lesakh USSR [The reserves of elements of soil nutrition of plants in the plain forests of the USSR]. *Prirodnye i trudovye resursy levoberezhnoi Ukrainy i ikh ispolzovanie [The natural and labor resources and their use in the left-bank Ukraine].* (Vol. 13). Moskva: Nedra [in Russian].
4. Lebedev, E.A., Pobedov, V.S. (1984). Migratsiya azota, kaltsiya, magniya i kaliya po profilyu dernovo-podzolistykh lesnykh pochv [The migration of nitrogen, calcium, magnesium and potassium along the profile of sod-podzolic forest soils]. *Pochvovedeniye — The Soil Science, 5*, 91–95 [in Russian].
5. Astapovich, A.V. Pochvenno-gruntovyye usloviya proizrastaniya sosnovykh kulturfitotsenozov mshistogo i chernichnogo tipov lesa Belarusskogo Polesia [The soil conditions for the growth of the phytocenoses of pine cultures in mossy and blueberry forest types in the Belarus Polissya]. *Problemy lesovedeniya i lesovodstva — Problems of forest science and forestry, 68*, 5–11 [in Russian].
6. Raspopina, S.P. (2010). Metodolohichni problemy otsinky lisoproduktyvnoi zdatnosti zemel, shcho vyvodiatsia iz silskohospodarskoho obihu [The methodological problems of assess of the forest productive capacity that are derived from agricultural circulation]. *Naukovyi visnyk NUBiP Ukrainy — Scientific Herald of NULES of Ukraine, 152, 2*, 163–170 [in Ukrainian].
7. Binkley, D., Fisher, R. (2013). *Ecology and management of forest soils.* 4th ed. Oxford: Wiley-Blackwell [in English].
8. Yatsuk, I.P. (2014). Analiz ahroekolohichnoho stanu gruntiv Zhytomyrskoi oblasti za dopomohoiu metodyky ekoloho-ahrokhimichnoi pasportyzatsii [The analysis of the agroecological conditions of soil in Zhytomyr region using the technique of ecological and agrochemical certification]. *Zemlekorystuvannia — Land using, 2*, 107–110 [in Ukrainian].
9. Vedmid, M.M., Raspopina, S.P. (2010). *Otsinka lisoroslynnoho potentsialu zemel: Metodychnyi posibnyk [Assessment of forest production of lands: Workbook].* Kyiv: Eco-inform Publ. [in Ukrainian].
10. Pochvy. Metod opredeleniya obmennoy kislotnosti pochvy [Soils. Method to calculate changing acidity]. (1986). *HOST 26484–85 from 1st June 1986* [in Russian].
11. *Metodicheskoe posobie po analiticheskim rabotam dlya agrochimicheskoy slyzhby Ukrainy. Chast 1 [Workbook on analytical works for agrochemical service of Ukraine. Part 1].* (1989). Kiev [in Russian].