FOREST REGENERATION AND FOREST GROWING

УДК 630.114.68:630.176.321/322

M. I. Antonik[1], V. M. Bosak[2]
[1]RUE "Belgosles"
[2]Belarusian State Technological University

THE SOIL CONDITIONS OF THE OAK STANDS IN THE SOUTH-WEST PART OF BELARUS

In the soil and climatic conditions of the oak stands (*Quercus robur* L.) grown installed: features of the state land-ground-water conditions on the water physical properties and moisture capacity; the regularities of distribution and content of nutrients were revealed; the granulometric composition of soil were established and the group and factional composition of humus were determined.

The studies found that in the Bialowieza Forest oak-woods grow on sod-podzolic and brown forest sandy and sabulous soils underlain by moraine loam. Oak-woods in the floodplains of Pripyat grow on floodplain sod gley sabulous soils with content of physical clay in humus horizons up to 20%.

Soil conditions of oaks by water-physical characteristics, moisture reserves and agrochemical indicators are better in floodplain forests, while by density and granulometric texture – in upland types of oak-woods.

Key words: soil, oak stands, water-physical characteristics, agrochemical indicators.

Introduction. English oak (*Quercus robur* L.) plantations in the Republic of Belarus occupy 248.0 thousand ha, that is 3.4% of the forested lands. Most plants grow in the oak woods of the south-west part of Belarus.

The productivity and the resistance of oak stands are determined by the soil conditions features of their growth, therefore to develop recommendations for their reproduction and formation of highly relevant is the study of the properties of oak plantations soils [1–5].

A study of soil conditions in upland and floodplain oak plantations were carried out on the test plots (PP) in Milevichi forestry area of GLHY "Zhitkovichi Forestry" in Pererovskiand Ozeranski forest areas of the GNP "Pripyatski" forming arange of typology ecological oak stands: brake fern, bilberry, oxalis, riverbed and floodplain, alder-floodplain, grass-floodplain, large grass-floodplain, lily of the valley-floodplain, sedge- floodplain, as well as in Korolevo Mostovski and Pashukovski forest areas of the GPU "NP "Bialowieza Puscha" – brake fern, bilberry, oxalis, glague, nettle, fern oak stands.

Silvicultural taxation and forest typology studies were performed by the methods of V. N. Sukachev, V. S. Zona, I. D. Yurkevich, V. S. Geltman. A detailed study was preceded by reconnaissance survey of woodlands.

The taxation of test plots was carried out by conventional methods of forest inventory (OST 56-69-83). Carrying out the work 42 test plots were laid with description of morphological features of genetic horizons in soil sections, measured the depth of the groundwater level, taking samples of water-physical and chemical properties for analysis.

Determination of water-physical and chemical properties of soils was carried out by the principles of I. K. Blintsov, N. I. Smejan, I. N. Solovyov, A. I. Gorbileva, V. G. Mineev. Under laboratory conditions, the maximum hygroscopiciy by Nikolaev, field humidity, granulometric structure by Kaczynski, the total density, the density of solid soil phase were determined, the porosity and deposits of moisure in the soil horizons were calculated, the content of organic C by Nikitin, of total N by Kjeldahl, of P by Sherman, $N_{e.\text{-}g.}$ by Cornfield, P_2O_5 by Kirsanov, pH_{KCl} by potentiometry method were defined.

The group fractional humus composition determination was carried out by the scheme of Tyurin modificated by Ponomareva and Plotnikova. While processing the data mathematics statistical methods (E. A. Dmitriev, P. F. Rokitsky, G. N. Zaitsev) were applied using Microsoft Excel XP standard package, data analysis was performed according to the procedures of A. Minko, G. Simon with standard Statistica 6.0 package.

Main part. In Bialowieza Puscha the brake fern oak stand differs by the greatest floristic richness in the summary of species (67 species), followed by oxalis, and fern oak stands (respectively 52 and 50 species).

The lowest number of species is in the nettle, glague and blueberry oak stands (respectively 48, 44 and 29 species). In Polesie the greatest number of species was found in the floodplain forest types: in large grasses-floodplain oak stand – 52, grasses-floodplain – 49. In riverbed and floodplain oak stand there were 23 species, alder-floodplain – 20, brake fern – 32, blueberry – 28, oxalis– 26, grass-floodplain and large grasses-floodplain oak stands – respectively 28 and 24 species. *Oxalis acetosella* L., *Pteridium aquilinum* (L.) Kuhn., *Convallaria majalis* L., *Majanthemum bifolium* (L.) F. W. Schmidt, *Vaccinium myrtillus* L., *Anemone nemorosa* L., *Trientalis europaea* L., *Pirola rotundifolia* L., *Aegopodium podagraria* L., *Stellaria holostea* L., *Carex pilosa* Scop., *Vaccinium vitis-idaea* L., *Fragaria vesca* L., *Asarum europaeum* L., *Calamagrostis epigeios* (L.) Roth, *Agrostis alba* L., *Galeobdolon luteum* Huds, *Luzula pilosa* (L.) Willd, *Urtica dioica* L., *Deschampcia caespitosa* (L.) PB, often occurin the living ground cover, patchy – *Pleurozium schreberi* (Brid.) Mitt., *Dicranum scoparium* Herdw., *Mnium affme* Bland ex Funck.

Oak stands of Bialowieza Puscha grow on sandy and sandy loam soils, developing on the moraine loams. Brown wood soils occur in small patches among sod-pale-podzolic soils, ranking higher well-drained areas, which are mainly represented by friable parent rocks; at a depth of 0.4 to 1.5 m they are underlying by moraine loams.

In the composition of explored silt soils the fractions of large and medium-grained sand(1.0–0.25 mm) prevailed with a low content of muddy fraction (<0.001 mm) – 0.34–7.24%. The content of physical clay soil species ranged from 2.55 to 25.90%, the amount of silt particles was 0.60–7.24%, of large grain soil – 2.13–10.49%.

The alluvium soils prevailed by grain size composition in the river Pripyat floodplain with the content of 15–20% of physical clay particles in the upper horizons. As part of slit soil, the fractions of 0.25–0.05 mm were predominant (from 18.46 to 91.59%).

Floodplain soils differed by profile stratification, developed humus horizon at the average PHKCl of 4.64 and accumulative nature of elements distribution in the profile with their maximum concentration in the upper layers.

The soil solid phase density of oak forests in Bialowieza Pushcha ranged from 2.35 to 2.87 g/cm^3. The lowest values (1.15–1.45 g/cm^3) were observed in the forest litter, that was specified by the composition and high content of organic matter. The maximum hygroscopicity value of all explored soils was not the same: the upper sand horizons contained in average 0.20%, the lower – as far as 1.11% of moisture, the upper sandy loamhorizons – 0.30%, the lower – 0.83%, the loamy horizons – respectively from 1.21 to 1.42%. The deposits of moisture in the soil layer of 0–20 cm were characterized by small volumes (<20 mm).

The deposits of moisture in the layer of 1.5 m were less than 145.36 mm in the nettle, 155.54–157.14 mm in oxalis, 207.46 mm in blueberry, in fern and oxalis cultures of oak forest types – respectively 171 86 and 182.29 mm, in brake fern – 104.15 mm (Fig. 1).

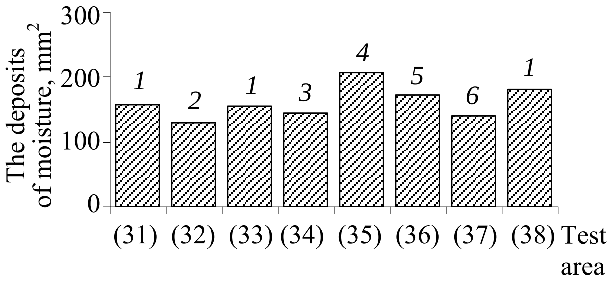

Fig. 1. Deposit of moisture in the 1.5 m soil layer of oak woods in GPU "NP "Bialowieza Puscha":
1 – Q. oxalidosum; *2* – Q. pteridiosum;
3 – Q. aegopodiosum; *4* – Q. myrtillosum;
5 – Q. filicosum; *6* – Q. urticosum

The porosity of the humus horizons was quite high (39.48–56.61%) with porosity of illuvial horizon 26.07–50.08%.

The 0.5 m sandy horizon of a brake fernoak stand contained 246.43 mm of productive moisture; large grass and cereal oak standswere characterized by a higher productive deposits of moisture (respectively 574.52 and 541.98 mm).

In the upper sandy loam horizon (0–30 cm) moisture reserves amounted 126.90 mm (maximum – 139.89 mm), in the lower layer (30–100 cm) – from 171.10 to 435.11 mm. The deposits of productive moisture in sandy horizons (0–30 cm layer) ranged from 50.27 to 57.18 mm. In the loamy layer at a depth of 65–150 cm the productive deposit moisture proved to 244.98 mm in the same layer at a depth of 70–150 cm – 131.83 mm, at a depth of 85–150 cm – 71.34 mm (Fig. 2 and 3).

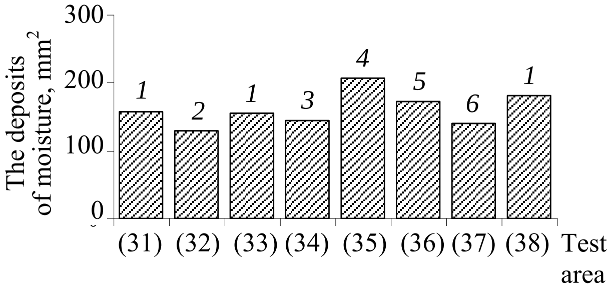

Fig. 2. The deposit of moisture
in the 1.5 m soil layer of Polesie oak stands:
1 – Q. oxalidosum; *2* – Q. pteridiosum;
3 – Q. aegopodiosum; *4* – Q. myrtillosum;
5 – Q. filicosum; *6* – Q. urticosum

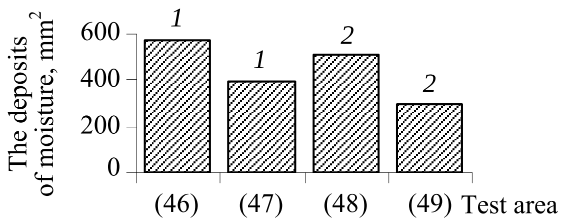

Fig. 3. The deposit of moisture in the 1.5 m soil layer in Pripyat oak stands: *1* – Q. nemoroso-fluvialis; *2* – Q. graminoso-fluvialis

The soil density of oak stands in Polesie was 0.25–0.40 g/cm^3 in forest litters, 1.06–1.65 g/cm^3 in humus horizons, 1.36–1.88 g/cm^3 in illuvial horizons with the density of the soils solid phase from 1.20 to 2.78 g/cm^3. Compared to the forest litters underlying soil horizons are relatively poor in humus content, which rangedin humus and podzolic horizons within 1.38–4.67%.

The illuvial and gley horizons contained a very low organic mass – from 0.08 to 0.65%.

The litters of Bialowieza Puscha's oak woods soils were characterized by a high content of organic carbon (C_{org}), which ranged from 20.85 to 36.95%. The total nitrogen content (N_{tot}) in oak forests soils litters of Bialowieza Puscha was 1,27–1,70%: in glague oak stand – 1.27%, fern – 1.30%, oxalis – 1.58–1.68%, bilberry – 1.70%. In podsolic horizons the total nitrogen content was decreased by 4–12 times, indicating a low mineralization degree of organic nitrogen-containing compounds composed of overrotten forest litter substrate (C:N = 14:1–22:1). In illuvial and underlying horizons the total nitrogen content decreased to very low values – 0.02–0.10% (C:N = 8:1–18:1).

The fraction of easily hydrolyzable nitrogen ($N_{e.-g}$) in brake fern and blueberry oak stands varied within 4–7% of the total nitrogen content. There was a similar distribution regularity both in forest litter (877.5–987.0 mg/kg), and in the soil horizons (from 68.5 to 526.5 mg/kg). Gross phosphorus content (P_{gr}) in the brown forest and sod-podzolic soils of oak stands in Bialowieza Puscha was 0.07–0.12% (supplies – from 0.27 to 1.05 kg/m^2) with maximum values in the forest litter of oxalis and blueberry types of oak plantations. The content of gross phosphorus was represented to a great extent by mineral phosphates, where the fraction of mobile phosphorus (P_2O_5) was 10–40% of the gross phosphorus supplies.

Upon the depth of 1.5 m and one square meter of the surface in view of soil horizons' thickness and density, potential humus supplies in the soil of Bialowieza oak stands equal to 15–24 kg/m^2 were calculated. Humus supplies (0.5–0.7% by weight of soil) were lower in the soils of glague oak stand and high – in oxalis, nettle and blueberry oak stands. Supplies of total N_{tot} ranged within 1.44–3.14 kg/m^2 at higher rates in soils bilberry and nettle oak stands, low – in oxalis and fern soils types of oak stands. Supplies of $N_{e.-g}$ reached 7–10% of the total nitrogen and prevailed in bilberry and nettle types of oak stands. The results of the potentiometric analysis showed that the soil horizons of studied Bialowieza oak stands had a strongly acid and acidic reaction mediums (PH_{KCl} 3.12–4.86).

The content of organic carbon (C_{org}) in Polesie oak forests litters of the Pripiat floodplains varied over a wide range – from 10 to 40% by dry weight. The greatest amount of organic carbon was represented in upland oak forest litters (brake fern, oxalis, blueberry – 26.35–40.75%). The humus content in humus horizons is 2.32–2.68%, in the illuvial horizons it decreased by 2–10 times.

The amount of total nitrogen in forest litters was less variable (from 1.06 to 1.80%). A high supply of nitrogen was marked in forest litters of alder floodplain (1.80%) and upland blueberry (1.68%) oak stands, a low content is specified in forest litters of brake fern oak stand (1.25%) and English oak specimen (1.00%). The total nitrogen content in the humus horizons sharply decreased to 0.17–0.80%.

Soils of Pripyat Polesie oak stands were characterized by a low content of gross phosphorus – from 0.03 to 0.09% (gross phosphorus stocks amounted 0.08–0.60 kg/m^2) with maximum phosphorus supplying offorest floodplain and upland brake fern and oxalis oak stands litters. The forest litters of Bialowieza old-growth oxalis and blueberry oak stands on sod-podzolic gley sandy loam soils have the ratio C:N = 22:1–27:1 shows the distribution of carbon by genetic horizons with a high mineral content in the humus horizon. These soils are characterized by a high thickness of forest litters and a high carbon and nitrogen content of organic matter (ratio C:N = 22:1–15:1, in the lower horizons – 10:1–5:1) indicating the average supplying of these soils with nitrogen available for plants. Humus in the upper part of the profile in the forest litter was characterized by average and humus in the forest litter and humus horizon by a high content of humic acids (HA) with ratio $C_{g.c}$:$C_{ph.kc}$ = 1.10–1.78.

At the bottom of the soil profile there is a decrease in the amount of humic acids and reducing this ratio as far as 0.24–0.88. The humus type in the forest litter and humus horizon should be attributed to fulvic-humate with a high degree of humification of organic matter. The fraction of humic acids associated with mobile oxides in the forest litter and mineral horizons, was low.

The content of calcium humates was low in the forest litter and increased the profile in the humus horizon up to 40% of humic acids summary; in the illuvial horizons, the content of humic acids decreased substantially, resulting in the fulvic acids content decrease. Humus composition of sod-podzolic gley sandy loam soils underlain by moraine loams was characterized by huminification degree of organic matterfrom medium to high genetic horizons of the soil profile. Fulvate-humate type of humus for a forest litter and humus horizon focuses on the upper part of the profile with the ratio $C_{g.c}$:C_{ph} from 1.0 to 1.5 with a high content of humic acids strongly bound. The quantitative part of the humic acids, free and combined with moving sesquioxides, is less important in comparison with a similar fraction of humus in the soil, exchangeable by sands, indicating lesser mobility of humic substances in thesabulous soils underlain by moraine loams.

In group composition humic acids are represented by all three fractions. The fraction associated with calcium varied from very low to medium-sized (2–40% of the HK summary); humification degree of organic matter in the forest litter and mineral horizons of the soil profile varied from low to high values (18–90% of the HK summary).

Conclusion. Oakwoods with low quality of locationdiffer from those of highly productivity by water-physical properties, granulometric composition, moisture conditions and agrochemical indexes. In Bialowieza Puscha oak woodsgrow on sandy and sabulous soils underlain by moraine loams. The solid phase density ranges from 2.35 to 2.87 g/cm^3, low values (1.15–1.45 g/cm^3) are characteristic for the forest litter. The thickness of the forest litter is 0.17–0.33 g/cm^3, soil horizons – 1.46–1.81 g/cm^3. The deposits of moisturein the layer of 1.5 m ranged from 145.36 to 256.16 mm. Oakwoods in the Pripyat floodplain grow on sod gley sabulous soils with physical clay content in the humus horizons as far as 20%.

By water-physical properties, moisture deposits and agrochemical indexes, the oak woods soil conditions are more favorable in the floodplain forests, by density and granulometric composition – in upland types.

References

1. Antonik M. I. The soil conditions of the ouk-woods in Bieloviezskaya Puscha. *Pochvovedenie i agrokhimiya* [Soil Science and Agrichemistry], 2012, no. 2, pp. 74–81 (In Russian).

2. Dobrovol’skiy G. V., Nikitin E. D. *Funktsii pochv v biosfere i ekosistemakh* [Soils functions in the Biosphere and Ecosystems]. Moscow, Nauka Publ., 1990. 260 p.

3. Romanova T. A. *Vodnyy rezhim pochv Belarusi* [Water regime of soils of the Belarus]. Minsk, Belaruskaya navuka Publ., 2015. 144 p.

4. Sokolovskiy I. V., Bespalyy A. A. Sod-podzolic groundwater cryptogley and groundwater gley soils of the Belarusian Polesye region. *Trudy BGTU* [Proceedings of BSTU], 2013, no. 1: Forestry, pp. 186–190 (In Russian).

5. McFee W. Jr., Stone E. L. Quantity, Distribution and Variability of Organic Matter and Nutrients in a Forest Podzol in New York. *Soil Science Soc. Am. Proc.*, 1965, vol. 29, pp. 432–436.

Information about the authors

Antonik Maryia Ivanauna – leading engineer. RUE “Belgosles” (27, Zheleznodorozhnaya str., 220089, Minsk, Republic of Belarus). E-mail: antonik@ministry.mlh.by

Bosak Viktar Mikalaevich – DSc (Agriculture), Professor, Head of the Department of Occupational Safety. Belarusian State Technological University (13a, Sverdlova str., 220006, Minsk, Republic of Belarus). E-mail: bosak1@tut.by

Received 28.01.2016