DOI: https://doi.org/10.5564/mjas.v21i02.908

THE INFLUENCE OF ARTIFICIAL FOREST PLANTATIONS ON SOIL PROPERTIES IN THE COASTAL ZONE OF LAKE SHIRA

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ABSTRACT

The materials on the influence of artificial forest plantations on the soil properties in the conditions of the dry steppe of Khakassia are discussed. The soil-improving effect of plantations of Siberian larch, Siberian elm-tree, joint plantations of elm and larch, as well as pine and caragana tree, through optimization of moisture mode, biogenic accumulation of elements and agrochemical properties of soils is established. Ecologically sustainable phytocenoses are formed.

KEY WORDS: *chestnut soils, ordinary chernozems, southern chernozems, agrochemical properties, artificial forest plantations.*

The steppe ecosystems of Khakassia region are very unstable and vulnerable. In this "deforested" area, the agrolandscape sphere can be disturbed in terms of deflated areas broadening, ravine development, river and water sources depletion, meadows and pastures desiccation, etc. The restoration of the optimal balance between the basic elements of the landscape – arable land, meadow, wood and water is the basis of landscape-system management. The comprehensive measures for the formation of ecologically stable ecosystems of the steppe regions of Russia (which is home of protective afforestation) always put the planting of forests in the form of tapes and bands in the first place (Petrov, 1991). Therefore, the creation of the long-standing, sustainable protection forest plantations that perform water protection, soil protection, sanitary-hygienic and aesthetic functions has the ecological importance in the steppe zone of Khakassia Republic. Experimental forest plantings according to special technology were created in 1978-79 in the coastal zone of Lake Shira. It is a therapeutic lake and it is located in the zone of a very intensive recreational load. The introduction of tree species here is restricted by many limiting factors – soil moisture deficit, high concentration of soluble salts, lack of nutrients, weak biological activity (Soil conditions.., 1975). Therefore root endings of the seedlings of tree species grown in Tuimskii and Shira nurseries, were pre-treated with growth stimulators of mycorrhizae growth (Sorokin, 1998). These are currently forest plantations of Siberian larch, Siberian elm, elm together with larch, pine, pine tree together with caragana. At the moment, the plantings have reached 35 years of age. Over a relatively short period of growth the forest plantations lead to the succession of ground cover, change the mode of soil properties

functioning. The purpose of the research is to assess the changes of some properties of virgin steppe soils under the influence of coniferous and deciduous species in the artificial forest plantations of the coastal zone of Lake Shira in comparison with the areas of old deposits (conditional virgin soil), located in the immediate vicinity. The main tasks of the research are:

- to study the dynamics of soil moisture;
- to analyze the changes in humus content, soil reaction (pH water), nitrate nitrogen ($N–NO_3$), ammonium nitrogen ($N–NH_4$), mobile phosphorus (P_2O_5) and exchange potassium (K_2O).

The soil cover of the coastal zone of Lake Shira is represented by a set of chestnut soils, southern chernozems and ordinary thin gravelly sandy loam or light loam soils. Under the artificial plantations – the objects of study – the ordinary carbonate medium-humus thin light loam chernozem soils are developed. According to the new classification they are classified as accumulative-carbonate dark agrozems, which are generally formed from the soil with the shortened humus horizon (Classification.., 2004). The general structure of these soils profiles is as follows: AUpa (PA) – BCAdc – Cca. The mode of soil moisture at soil layers 0-10 and 10-20 cm was studied with the help of the gravimetric method. The selection of soil samples was carried out in five-fold repetition in the middle of June, July, and August. In these samples the content of humus by Tyurin, pHwater ion-metrically, $N-N0_3$ by disulfonic method in the modification of Sharkov, $N –NH_4$ with the help of Nessler's reagent, P_2O_5 and K_20 by Chirikov was determined. The determination of field soil moisture under the artificial forest plantations of different species composition revealed the following regularities:

- moisture content under all tree plantations in the topmost soil layer (0-10 cm) in all periods is higher than in the layer of 10-20 cm;
- in the first and second determination terms the values of moisture are optimal and higher of wilting moisture content;
- by the third term (August) the moisture content is reduced and approaches the moisture content of wilting due to the intense consumption of moisture by the vegetation;
- maximum amount of moisture is recorded in the second term after summer rains;
- the most moist soil in the first term is under the pine tree, together with acacia, then under the elm;
- in the second and the third determination terms the driest soil is under the pine tree;
- the highest content of moisture in the soil in the second and third terms is on the virgin soil (near pine trees and acacia);
- for the vegetation period (end of season) joint plantations of pine and acacia, elm a larch, and larch consume most of the moisture;
- in the most critical periods of the growing season (July) when there is intensive use of moisture by woody and herbaceous plants, the moisture content of soils is optimal for their needs provision.

The role of humus in the formation of ecological stability of natural and agrogenic biocenoses, their functioning and possible directions for their use is huge. The natural recovery of forests in the forest-steppe and steppe zones, as well as artificial forest plantations of different species composition, determine the humus condition of soils. It depends on the conditions of heat and humidity provision, age of the forest stands, the successional stage of ground vegetation and litter formation. The new conditions of the plant growth and activity of entomo-fauna and microorganisms, inhabiting soil, due to the impact of forests have a great influence on the processes of accumulation, transformation, mineralization and humification in soil. The active influence of forest canopy on soil properties starts with the formation of the specific horizon of forest soils and forest litter. The phenomenon of stratification of the forest litter is the most visible result of the flowing succession. We observed the formation of forest litter in the following increasing line of artificial plantations: elm - elm+larch - larch - pine +caragana – pine. Under the stands of pine and larch the more powerful litter is formed, which begins to differentiate into two layers according to the degree of decomposition. The optimum conditions for the formation of the effective fertility under the influence of forest plantations are proved by the intensive development of mushroom mycelium underneath, which is involved in many processes of mineralization and performs, along with micromycetes, the role of hydrolytical substances. The brightest “mycelium” is formed at the contact of the forest litter and upper mineral soil part under the coniferous species. Abundant mushroom mycelium permeates the mineral part of the soil, and in some local places fuses with the soil and litter. There are significant differences according to the content of humus in forest plantations of different species: from low to high level of humus content. The content of humus in the layer of 0-10 cm is much higher compared to the layer of 10-20 cm. The highest amount of humus is found on the virgin soil near pine trees and in the virgin soil next to the larch – 9,6 and 7,4% in the layer of 0-10 cm and 6,9 - 6,4 % at a depth of 10-20 cm, respectively. Under the joint plantations of pine and caragana there is a sharp decrease of humus content by almost 2 times, particularly in the layer of 10-20 cm. There is a slight decrease in the

content of humus under conifer species. For example, in the soil layer of 0-10 cm under the planting of the elm, the average humus content is 5,7 %, and under the larch in the same layer it is 3,9 %, while these areas are located in close proximity to each other and on the same soil type. This decrease of humus content under the larch and elm with larch is observed due to more intensive mineralization of organic litter. The maximum influence on the soil reaction change is manifested from mid-July to the end of August due to receipt of fresh organic litter matter and decomposition of dying mass of woody and herbaceous plant roots. Maximum acidifying effect on the soil is provided by artificial plantations of pine (pHwater 6,0 - 6,35) versus 6,9-7,1 under the plantation of elm, and 6,7 - 7.2 in the virgin areas. In comparison with virgin soil no clear regularity of pH reduction in soil under deciduous species (elm), coniferous species (larch) and mixed plantations (elm+larch) is determined. Thus, according to the results of soil reaction determination, the soil-spoiling influence of artificial wood plantations on the dry steppe soils of the coastal zone of Lake Shira is not determined. On the contrary, there is the dealkalization of the soil solution. The litter of woody species in the artificial plantations shows greater ash content, higher nutrient content and average nature. Decomposition products of this litter influence the soil not so aggressively and it does not lead to its considerable acidification, but leads to optimization of the pH value. Statistically significant acidifying effect on the soil is found only in pine plantations under optimal conditions of the atmospheric moisture. This effect is not manifested in dry conditions (Kuular, 2011). The ammonium form of nitrogen is dominant in the soils under the artificial forest plantations. The limiting factors of nitrification are frequent desiccation and high soil temperatures, small quantities of organic matter. The provision of soil ammonium nitrogen in different determination terms ranges from low (6,8-8,0 mg/kg of soil) to high (12,4-14,4 mg/kg of soil). The minimum amount in the soils of all the objects is observed in mid-June, due to intensive use of nitrogen by the actively growing aboveground phytomass of the herbaceous cover and tree stands. Under the tree plantations the absorbed ammonium content, as a rule, is lower (7,0-9,6 mg/kg of soil) than in virgin soil (9,8-12,4 mg/kg of soil), due to more intensive use of nitrogen by vegetative mass of woody plants. Despite the higher removal of nitrogen by forest stands, its content in the soil is not reduced significantly compared to virgin analogues. This testifies to the intense ongoing microbial processes under the forest canopy, leading to the formation of ammonium nitrogen. As a result, the effective soil fertility is not reduced under the influence of artificial forest plantations. The content of nitrate nitrogen in the soils is relatively low and practically does not go beyond the 2-3 provision class, that is, low and medium. In the soils under the artificial forest plantations, as a rule, the nitrate nitrogen content is less than in areas of virgin soil (old fallow), especially in the second determination term when the hydrothermal conditions are optimized. By mid-summer the content of nitrate nitrogen is drastically reduced under almost all forest species. By the end of the vegetation season (mid-August), due to precipitation in July, and the optimum temperature, the intensity of nitrification increases and, therefore, the nitrate content increases as well. Unlike humidity, the content of nitrate in the layer of 0-10 cm is lower than in the layer of 10-20 cm, which is associated with better moisture availability of the soil layer. The highest amount of nitrate nitrogen during the vegetation season is found under larch and in the virgin soils near larch. Maximum differentiation of the upper layer of soil is typical on the content of ammonia nitrogen, mobile phosphorus and exchange potassium, indicating to biogenic accumulation, in both virgin soils and artificial forest plantations, which is statistically confirmed. The identified properties of soils indicate to the formation of optimal conditions for the growth of artificial forest plantations of different species composition. This is reflected in the good mycorrhization of root endings, especially in coniferous species, the absence of infections, diseases of woody plants, their abundant seed production and satisfactory reforestation.

Thus, the assessment of soil properties of the studied objects shows their transformation under the influence of artificial plantations of different tree species. The ecological significance of these plantations in the steppe zone of Khakassia is huge due to the fact that such landscapes require special protection and nature management. Further soil fertility monitoring of these unique model anthropogenic ecosystems is a priority and an urgent task to create the sustainable landscape system management of this zone.

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