ASSESSMENT OF THE STATE AND RESTORATION OF BIOLOGICAL RESOURCES OF SCOTS PINE (PINUS SILVESTRIS L.) IN THE SOUTH OF THE CENTRAL RUSSIAN UPLAND

ASSESSMENT OF THE STATE AND RESTORATION OF BIOLOGICAL RESOURCES OF SCOTS PINE (PINUS SILVESTRIS L.) IN THE SOUTH OF THE CENTRAL RUSSIAN UPLAND

V I Cherniavskih[1,2], E V Dumacheva[1,2], E I Markova[3]

[1]All-Russian Research Institute of Phytopathology, 5 Ownership, Institute St., r.p. Big Vyazemy, Odintsovo district, Moscow region, 143050, Russia
[2]Federal Williams Research Center of Forage Production & Agroecology, 1 building, Scientific town, Lobnya, Moscow region, 141055, Russia
[3]Belgorod State University, 85, Pobedy St., Belgorod, 308015, Russia

E-mail: abramovam2016@yandex.ru

Abstract. The paper deals with an assessment of the current state and prospects for the creation of artificial forest plantations based on Pinus silvestris L. to increase the bio resource potential of the south of the Central Russian Upland. There have been tested and methodically substantiated various methods of creating long-term forest plantations based on Pinus silvestris L. by improving the methods of sowing seeds. Evaluation of the effectiveness of various methods of sowing pine has shown that more guaranteed and uniform seedlings and further development of seedlings provide sowing with cones. Having an equal number of seed holes when sowing with seeds and cones, it can be stated that the number of holes in which seedlings appeared during sowing with cones is 56.8% higher, the survival rate of seedlings is 34.6% higher, the number of seedlings is 25% higher, and the number plants per hole – by 50%. Sowing with cones is economically more profitable - no need to engage in costly threshing of seeds; cones are easier to plant during mass plantings in the process of laying artificial forest plantations; cones have a high hygroscopicity, the seeds are constantly in a moist state and germinate well, regardless of the conditions of soil and air moisture.
Key words: artificial plantings of chalk pine, methods of reproduction, methods of creating artificial plantations, sowing pine with seeds, sowing pine with cones.

1. Introduction

A specific feature of the south of the Central Russian Upland is unstable and insufficient moisture, specific soil conditions, high economic development and a low area of forest vegetation.

In this regard the primary scientific task is to analyze the state, dynamics and geography of tree and shrub vegetation, both in natural conditions and artificially created tree and shrub plantations, and the development on this basis of applied principles of their rational use and reproduction [Kaygorodov et al., 2018; Neverov et al., 2019; Valeeva et al., 2019].

Reforestation can be carried out by the method of natural, artificial, as well as combined reproduction of forests. Natural restoration of forests is preservation of undergrowth of forest tree species during

felling of forest stands, soil mineralization, burning, etc. [Atutova, 2019; Basyuni et al., 2020; Ceacero et al., 2020; Chen et al., 2020].

Artificial forest restoration is carried out through the creation of forest plantations. In this case, the development of methods for its implementation is of great importance. This problem and ways to solve it are also considered in the published works of foreign scientists [Creevy et al., 2020; Liz et al., 2020; Shangbin et al., 2020; Tinya et al., 2020].

The "Green Capital" project has been implemented in the Belgorod region since 2010. Its concept is a unique example of artificial reforestation in the Russian Federation. One of the directions of this project is the continuous afforestation of chalk slopes and erosion-hazardous areas, the cultivation of planting material, the landscape arrangement of settlements [Government Decree ..., 2010].

As part of the implementation of this direction, it is planned to create more than 100 thousand hectares of forest plantations on chalk slopes and erosion-hazardous areas of the region for 2010 - 2020, that is, bringing the forest cover of the region to 15 % – the optimal value for our territory. For the period 2010 - 2018, the establishment of forest plantations was made on the territory of 87.7 thousand hectares. This is 87 % of the implementation of the plan of the entire project being implemented [State report ..., 2016].

The most important crop for reforestation is the pine culture. Scots pine (*P. silvestris* L.) and chalk pine (*P. silvestris* Kalenicz) grow on the territory of the region (Fig. 1).

P. silvestris Kalenicz (cretaceous or chalk pine) is an endangered species of Scots pine in the region. It is a tree up to 40 m high.

Cretaceous pine (*P. silvestris* Kalenicz) differs from Scots pine (*P. silvestris* L.) in smaller cones, low, curly crown and shorter needles. It grows on chalk outcrops. Natural regeneration of *P. silvestris* Kalenicz occurs well on washed-out humus-calcareous soils and chalky outcrops and is difficult on soddy soils and in the presence of a layer of dead litter. It is endemic to the Central Russian Upland.

P. silvestris Kalenicz is distributed along the banks of the rivers Don, Potudan' (Voronezh region), Oskol, Nezhegol, Korocha, Koren' (Belgorod region), as well as Seversky Donets (Ukraine).

Figure 1. Cretaceous pine (*P. silvestris* Kalenicz) (photo by V.I. Cherniavskih)

P. silvestris Kalenicz is found in the Belgorod region in the village of Stenki-Izgorya of the Novooskolsk region; in the Bekaryukovsky pine forest and in the villages of Logovoe, Arkhangelskoe, Churaevo of the Shebekino region; near the village of Chernyanka of Chernyanskiy district. Species extinction risk: the development of chalk quarries in the places where chalk pine grows, as well as the activity of wild boar are factors recognized as threatened with extinction in this species of pine.

A variety of Scots pine (*P. silvestris* L.) – cretaceous pine (*P. silvestris* Kalenicz) grows on the territory of the Stenki-Izgorya section of the "Belogorie" reserve, on the territory of the specially protected natural areas of regional significance Bekaryukovsky pine forest.

Methods for increasing the survival rate of pine are being actively studied in laboratory studies. The influence of growth stimulants, prospects for micropropagation and other techniques are being investigated [Magyar et al., 2008; Kuneš et al., 2016; Lebedev, Schestibratov, 2013].

Research less often is carried out directly under the conditions of production tests when creating artificial plantations.

The purpose of the research was to assess the effectiveness of various methods of creating artificial forest plantations of pine in various districts of the Belgorod region.

2. Methods and materials

Sowing of plots of P. silvestris L. in the Belgorod region was being carried out annually, starting in 2010 in the autumn-spring period. Statistical material was being collected on the territory of 22 districts of the region. To compare and summarize the data obtained, the areas of the region were divided into three zones in accordance with the natural and climatic features:

- Western (Graivoronsky urban district, Krasnoyaruzhsky, Borisovsky, Rakityansky, Ivnyansky and Yakovlevsky districts);
- Central (Belgorodsky, Prokhorovsky, Korochansky, Novo-Oskolsky and Chernyansky districts and Gubkinsky, Starooskolsky and Shebekinsky urban districts, Belgorod);
- South-East (Alekseevsky and Valuisky urban districts, Krasnogvardeisky, Krasnensky, Volokonovsky, Veydelevsky, Rovensky districts).

In order to assess the effectiveness of the creation of artificial forest plantations studies were carried out on the following two methods of creating forest plantations of Scots pine. The first option is group sowing of seeds in the nests; the second option is sowing with cones in the nests. Furrows for planting plant material were cut with a tractor, then the plants were planted manually using Kolesov's sword – a device for manual planting of seedlings and saplings of forest crops. The sword consists of a metal wedge-shaped slab (plate) which is a working body and a rod with a transverse arm for the worker. The slab is 38 cm long, 10–13 cm wide and 2.5–3 cm thick on top. To make it rigid Kolesov's sword has a segmented profile in its cross section, and its lower part has a rounded shape. The sides and bottom end of the slab are sharpened. The rod (stalk) is cylindrical, 58 cm long and 2.5–3 cm in diameter. The weight of the sword is 4–5.4 kg; length is 90–105 cm and depends on the type of soil, as well as the height of the person using it. Depending on the soil and the height of the workers, the size and weight of the swords may vary. The length of the blade usually does not change [Zaborovskiy, 1938].

To process the data obtained, we used the MS Office (Excel) and Statistica 6.0 software package [Dospekhov, 2012].

3. Results and discussion

The planted *P. silvestris L.* in the region accounts for 13.2 % of the area of artificial plantations. The maximum planting area of *P. silvestris* L. is located in the Central part (Veidelevsky district) and the South-Eastern part (Starooskolsky urban district) - more than 1200 hectares.

Table 1 presents data on the assessment of the survival rate of *P. silvestris L.* in different zones of the region during reproduction by seedlings based on the results of the summary inventory.

During the reproduction of *P. silvestris L.* in the Western Zone the maximum planting area was in 2010, with 40% being planted with seedlings, and 60% with seeds. In 2018 the planting area decreased by 70 %. Moreover, 45 % were planted with seedlings, and 55 % with seeds.

In the Central Zone the planted area was also maximum in 2010, with 42 % being planted with seedlings and 58 % with seeds. In 2018, the area under pine crops decreased by 73%. Half of the sown area was made up of seedlings and in the second half the pine was sown with seeds.

In the South-Eastern zone, the area under pine planting in 2010 was also the maximum, with 47 % being planted with seedlings and 53 % with seeds. In 2018 the total pine planted area decreased by 70%. At the same time the area of plantings with seedlings was 20 % of their total area.

With all the methods of reproduction, the pine had a high average survival rate – at the level of 64.0% in the western part of the region, 67.5% in the Central and 61.0% in the South-East.

Table 1. The survival rate of *P. silvestris L.* in different zones of the region during reproduction by seedlings and seeds

Breeding method	Zones of the Belgorod region								
	Western			Central			Southeastern		
	Planting area, hectares/ year		Average survival rate,%	Planting area, hectares/ year		Average survival rate,%	Planting area, hectares/ year		Average survival rate,%
	2010	2018		2010	2018		2010	2018	
Seedlings	300	100	66	320	105	68	420	37	62
Seeds	450	120	62	450	100	67	470	150	60

Thus, there is a general tendency towards a decrease in pine planting areas in all zones of the Belgorod region - from 1,040 hectares in 2010 to 242 hectares in 2018 (by 4.2 times).

In order to assess the effectiveness of the creation of artificial forest plantations, studies were carried out on various methods of creating forest plantations of Scots pine by sowing seeds: group sowing of seeds in nests; sowing with cones. The results of the experiment are shown in Table 2.

Table 2. Assessment of methods for creating common pine forest plantations by sowing seeds (2017-2018)

Sowing method	Estimated indicators	M±m	lim	σ	Cv, %
Nesting with seeds	Number of seed holes for sowing, pieces / 100 m^2	29.1±2.3	22.0-32.0	3.1	10.6
	Number of seeding holes with shoots, pieces / 100 m^2	17.4±3.1	11.0-26.0	4.4	25.0
	Survival, %	60.3±12.8	36.7-81.3	15.5	25.7
	Number of seedlings, pieces / hole	2.8±0.8	1.0-4.0	1.0	36.9
	Number of plants per hole, pieces	1.2±0.8	0.0-2.0	0.9	76.6
Sowing with cones	Number of seed holes for sowing, pieces / 100 m2	28.8±3.2	22.0-34.0	4.0	13.9
	Number of seeding holes with shoots, pieces / 100 m^2	27.3±3.1	21.0-33.0	3.8	14.0
	Survival, %	94.9±3.2	89.3-100.0	3.9	4.1
	Number of seedlings, pieces / hole	3.5±0.8	2.0-5.0	1.0	27.8
	Number of plants per hole, pieces	1.8±0.3	1.0-2.0	0.4	23.4

With an equal number of seed holes for sowing with seeds and cones, the number of seed holes with saplings increased by 56.8 %. The survival rate of plants when planted with cones was significantly higher than when planted with clean seeds – by 34.6 %. It varied less depending on soil and relief conditions. The number of saplings when sowing with cones increases by 25 % and the number of plants

per hole – by 50 %. Ultimately, by 2018, the number of pieces in the holes averaged 1.8 (Cv = 23.4 %) when planted with cones, and 1.2 pieces (Cv = 76.6 %) when planted with clean seeds.

Thus, it has been established that the method of creating common pine plantings by sowing seeds is not promising. This is due to the fact that when seeds get into the soil, especially on sandy soils, they are often subjected to the negative influence of the environment, namely, the processes of drying seeds due to their low water-holding capacity. In fact, the swollen seeds dry out and lose their germination. Sowing with cones is a technique that allows to create more efficiently forest plantations.

4. Conclusion

Based on the data obtained it is recommended to sow with cones to improve the forestry system in various zones of the Belgorod region.

Sowing with cones is economically more profitable – it does not need to engage in costly threshing of seeds.

Cones are easier to plant during mass plantings in the process of laying artificial forest plantations.

Cones are highly hygroscopic; the seeds are constantly in a moist state and germinate well, regardless of the conditions of soil and air moisture.

Thus, sowing with cones provides more guaranteed and uniform seedlings and their further development.

References

[1] Valeeva, G.R., Karpov, M.V., Khafizova, Z.M., Gabdrakhimova, V.A., 2019. Delayed fluorescence from Pinus silvestris leaves as an indicator of urban environmental quality. IOP Conference Series: Earth and Environmental Science, 705: 022241.

[2] Kaygorodov, K.L., Tarabanko, V.E., Chernyak, M.Y., Chelbina, Y.V., Tarabanko, N., Smirnova, M.A., 2018. Kinetics of low-temperature oxidation of enzymatic lignin from pine wood (Pinus silvestris) in an aqueous alkaline medium. Russian Journal of Bioorganic Chemistry, 44 (7): 839-844.

[3] Neverov, N.A., Belyaev, V.V., Chistova, Z.B., Kutinov, Y.G., Staritsyn, V.V., Polyakova, E.V., Mineev, A.L., Tyukavina, O.N., 2019. Influence of morphometric parameters of relief on macro- and microstructure of wood pinus silvestris l. in the north of the Russian plain. Journal of Forest Science, 65 (2): 79-85.

[4] Atutova, Z.V., 2019. Features of reforestation in the longterm agricultural use of geosystems of the Tunkinskaya depression. IOP Conference Series: Earth and Environmental Science, 381 (1): 012003. doi:10.1088/1755-1315/381/1/012003.

[5] Basyuni, M., Slamet, B., Sulistiyono, N., Bimantara, Y., Widjaja, E.A., 2020. Species composition and plant diversity of logged-over forest in Sikundur, Gunung Leuser National Park, North Sumatra. IOP Conference Series: Earth and Environmental Science, 374 (1). 012051. doi:10.1088/1755-1315/374/1/012051

[6] Ceacero, C.J., Díaz-Hernández, J.L., Campo, A.D.D., Navarro-Cerrillo, R.M., 2020. Soil rock fragment is stronger driver of spatio-temporal soil water dynamics and efficiency of water use than cultural management in holm oak plantations. Soil and Tillage Research, 197. URL: http://doi.org/10.1016/j.still.2019.104495.

[7] Chen, P., Zhou, M., Wang, S., Zhu, B., Wang, T., 2020. Effects of afforestation on soil CH4 and N2O fluxes in a nsubtropical karst landscape. Science of the Total Environment, 705. URL: http://doi.org/10.1016/j.scitotenv. 2019.135974.

[8] Creevy, A. L., Payne, R.J., Andersen, R., Rowson, J.G., 2020. Annual gaseous carbon budgets of forest-to-bog restoration sites are strongly determined by vegetation composition. Science of the Total Environment, 705. URL: http://doi.org/10.1016/j.scitotenv.2019.135863.

[9] Kotlyarova, E.G., Cherniavskih, V.I., Dumacheva, E.V. 2013. Ecologically Safe Architecture of Agrolandscape is basis for sustainable development. Sustainable Agriculture Research, 2 (2): 11–24.

[10] Ota, L., Herbohn, J., Gregorio, N., Harriso, S., 2020. Reforestation and smallholder livelihoods in the humid tropics. Land Use Policy, 92. URL: http://doi.org/10.1016/j.landusepol.2019.104455.
[11] Shangbin Bai, Wanting Qiu, Hui Zhang, Yixiang Wang, Frank Berning Soil respiration following Chinese fir plantation clear-cut: Comparison of two forest regeneration approaches // Science of The Total Environment. 2020. Vol. 709. URL: http://doi.org/10.1016/j.scitotenv.2019.135980.
[12] State of World's Forests 2010. Food and Agricultural Organization of the United Nations. Rome, 2012: 60.
[13] Tinya, F., Kovács, B., Aszalós, R., Németh, C., Ódor, P., 2020. Initial regeneration success of tree species after different forestry treatments in a sessile oak-hornbeam forest. Forest Ecology and Management, 459. URL: http://doi.org/10.1016/j.foreco.2019.117810.
[14] Kuneš, I., Baláš, M., Linda, R., et al., 2016. Effects of brassinosteroid application on seed germination of Norway spruce, Scots pine, Douglas fir and English oak. Forest. Biogeosciences and Forestry, 10; 121-127.
[15] Lebedev, V., Schestibratov, K., 2013. Effect of natural and synthetic growth stimulators on in vitro rooting and acclimatization of common ash (Fraxinus excelsior L.) microplants. Natural Science, 5 (10): 1095- 1101.
[16] Magyar, L., Barancsi, Z., Dickmann A., Hrotko, K., 2008. Application of biostimulators in nursery. Bulletin of the University of Agricultural Sciences& Veterinary, 65 (1): 515.
[17] Decree of the Government of the Belgorod Region dated 25.01.2010 No. 35-rp "On the concept of the regional project "Green Capital". URL: httr://belregion.ru/documents
[18] State report on the state and use of land in the Belgorod region in 2015. Belgorod, 2016: 79.
[19] Zaborovsky, EP, 1938. Forest crops. M .: Gostekhlesizdat: 212-213.
[20] Dospekhov BA Method of field experiment (with the basics of statistical processing of research results). M .: Book on Demand, 2012.352 p.