Improvement of environmental efficiency of plants of green zones by creation of subordinate crops of Siberian stone pine

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Abstract. It is topical to increase the ecological efficiency of plantings of green zones of settlements by creating Siberian stone pine crops. The subordinate crops of this type, which were created in 1966 by quadrennial seedlings of different geographical origin at thick planting, were observed (9 pieces in a site measuring 0.7 x 0.7 m, the distance between the centers of the sites is 4 m). It was found that the canopy closure of the stand, consisting of birch and pine, has a significant effect on the growth rates of subordinate crops of Siberian stone pine. So at canopy closure 0.1-0.15 52 years old crops, despite the different geographical origin, had the highest rate of height, stem diameter, crown, number and diameter of lateral branches on the lower live node in comparison with the closure of 0.6-1.0. Average increment of branchlets at 32 year period was by 49.8% more in trees, growing at a canopy closure of 0.2 against 0.7-0.8. Trees growing on the open area characterized by early seeding, were selected and propagated by engrafting.

1. Introduction

Siberian stone pine (Pinus sibirica Du Tour) is one of the main timber species which is characterized by ecological efficiency, as evidenced by studies reflected in numerous literary sources [1-5].

There is an experience of growing cedar plantations both under the canopy of other forest-forming species, and in open areas. Studies of the growth of crops of woody plants under different intensity of illumination have shown that the species of woody plants are subdivided into long and short-days [6-10, etc.]

It was found that Siberian stone pine is a long-day plant. The best growth of plants of this species was noted under additional illumination [11, 12]. This probably explains the most intensive growth, the early seeding of Siberian stone pine trees in open areas, than under the forest canopy [13, 14, etc.].

It is noted that the growth of Siberian stone pine under the trees canopy can be adjusted, reducing the canopy closure by carrying out cuttings and selecting of planting material, which is grown on the basis of selection of fast-growing specimens growing under these conditions.

The purpose of our research was to establish the peculiarity of the growth of 56-year-old Siberian stone pine, which grows in subordinate crops, created in the spring of 1966 using four-year seedlings of different geographical origin (Altaic, Biryusin, Buryat, Kemerovo, Tomsk, Chita) Gorniy-2 ", located in the green zone of Krasnoyarsk.
2. Materials and methods
To create subordinate crops of Siberian stone pine seeds were harvested in populations growing under various growth conditions: from 50° 16' to 56° 30' N, from 84° 48' to 108° 43' E., from 100 to 1000 m above sea level, II-IV classes of bonitet, IV-VII classes of age, with Siberian stone pine in the composition of the stand from 3 to 9 units, forest types – mixed herbs, moss and cowberry Siberian pine forests.

Crops were created at a thickened planting. In each site 0.7 x 0.7 m under Kolesov’ planting iron 9 seedlings were planted. The distance between the centers of the sites was 4 m. Each variant consisted of 80 sites, including 720 plants. After 52 years, 1 to 7 trees were preserved in the sites. Statistically, such indicators as height, increments of branchlets, diameter, stem volume, crowns, etc. were measured and processed in the leading trees in the sites according to existing methods.

3. Results and discussion
Research has shown that canopy closure has a significant effect on all biometric indicators of trees. The best growth and formation of the crown were observed in trees growing at a lower canopy closure of the stand, the lag in growth was observed with its increase. It was noted that trees grown from Buryat seeds (the progeny of the population 50° 16' N, 106° 30'E, 1000 m above sea level, III class of origin) were more affected by shading.

With the canopy closure of the stand 0.1-0.5, the highest values in the subordinate crops of the leading trees are observed according to the following biometric indicators: height, shoot growths over the last four years, diameter of the trunk, crown, number and diameter of the lateral branches on the lower node in comparison with cultures that grow at a canopy closure of 0.6-1.0. There are no differences in the angle of attachment of the lateral branches of the lower living node to the trunk, which fluctuated depending on a canopy closure of stand from 92.3 to 92.9°.

A study of the increment of shoots over a 32-year period at different canopy closure showed significant differences in increment of shoots: when the canopy is closed, the average periodic increment is 49.8% higher in comparison with 0.7-0.8 (figure 1).

![Figure 1. Increment of shoot of model trees over a 32-year period at a different canopy closure](image-url)
At the same canopy cloure (0.5-0.6), differences in the intensity of growth of trees are observed depending on the geographical origin. The highest indicators for height, the current increment of shoots, the diameter of the trunk were in the trees of Altai, Chita origin. The trees of Chita origin have the best indices for the current increment of a shoot, the diameter of the trunk, the length, the diameter and the volume of the crown (the place of growth of the mother plantations: 50 ° 22`N, 108 ° 43`E, 700 m above sea level, class IV of bonitet).

Ranking of Siberian stone pine on the sum of the points characterizing intensity of growth and formation of a crown, has shown, that on the first places there are trees of the Chita and Altaic origin. Place of growth of the Altai maternal population: 51 ° 50`N, 86 ° 54`E, 500 m above sea level, III class of bonitet.

Comparative analysis of the growth rate of trees depending on the place of collection of seeds with the same canopy closure showed that the place of growth of parent plantations when creating subordinate crops affects biometric indicators of seed progeny. Significantly large indicators characterizing the intensity of growth and the formation of a crown, were in the seed progeny of trees from the plantations of mountain taiga and mountain-black forest seeded subareas.

There is a correlation link in variants of different geographical origin in subordinate crops between trunk diameter and height (r) from 0.350 of Chita origin to 0.872 of Kemerovo origin; the diameter of the trunk and the volume of the crown - from 0.543 of Altaic to 0.871 of Tomsk origin; crown diameter and crown volume - from 0.775 of Buryat origin to 0.942 of Chita origin.

High variability of biometric indicators among leading trees in geographical crops is noted, which indicates the manifestation of individual variability and the possibility of selecting valuable specimens regardless of their geographical origin.

Among the progeny of the maternity populations, the trees were selected, which are characterized by the most intensive growth and increased ecological efficiency for the purpose of growing varietal planting material for the creation of subordinate crops of Siberian stone pine in the green zone of Krasnoyarsk. Trees characterized by early and abundant seeding in the area where they grow in an open area are selected. The selected trees were propagated by engrafting using 7-year-old seedlings of Siberian stone pine as a stock. The best ramets are recommended to use for creating cedar plantations, which will have not only ecological but also economic importance, supplying the population with pine nuts.

4. Conclusions
The creation of Siberian stone pine crops in order to improve the ecological efficiency of existing plantations and in open areas should be justified by the use of planting material selected by economic features. It is necessary to carry out cuttings to reduce canopy closure to 0.5 in the created subordinate crops.

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