Growth and formation of cones of 56-year-old Siberian Cedar trees in geographical plantings

R N Matveeva, O F Butorova, N A Schenmaier and S N Dyrdin

Department of plant breeding and gardening, Reshetnev Siberian State University of Science and Technology, 31 Krasnoyarskii rabochii, Krasnoyarsk, 660037, Russian Federation

E-mail: schenmaier@yandex.ru

Abstract. The variability of the Siberian cedar in terms of the intensity of growth and yield, growing on the site “Continuation of the geoschool” in the suburban area of Krasnoyarsk, is considered. The trees were grown from the seeds of the Tanzybei (Krasnoyarsk Territory) and the Altai (Altai Republic) populations. The layout is 4x4 m. The height, diameter of the trunk, crown, and the number of cones on the tree have been determined. It was found that the average height of trees of different geographical origin is 11.5 and 12.9 m, the trunk diameter is 24.6 and 25.2 cm, respectively. The level of variability of growth indicators is medium and high. The number of cones on the tree ranged from 10 to 159. Trees were selected that differ in growth intensity and yield for the cultivation of selective planting material.

1. Introduction

The study of the polymorphism of woody plants is one of the main measures for the preservation of their biodiversity. Within the range, natural populations of Siberian cedar are characterized by high genetic potential, which is the basis for the selection and further breeding research.

Creation of geographical cultures of woody plants allows to identify the most productive populations and forms for collecting seeds and efficient cultivation of this species under certain growing conditions [1, 2, 3, 4].

Geographic cultures of the main forest-forming species have been created abroad since 1887, and in Russia since 1896. Indicators of geographical crops are a characteristic of the success of the growth of offspring and help identify the differences between them when growing in new conditions. According to the literature, it was established that crops from local seeds were more stable and productive. A promising selection of seeds in some populations is noted. The offspring of these populations is distinguished by high rates of growth and productivity. At the same time, the boundaries of seed transfer in latitudinal and longitudinal directions were determined [5, 6]. Thus, M A Nikolaeva et al. [7], after the researches on the growth of the offspring of 26 climatypes in 48–50-year-old geographical cultures of Siberian larch in the Republic of Bashkortostan, found that it is advisable to use seeds of this species with their transfer from the south to 2 °, north - up to 1 °, east - up to 3 ° 40 ′. They note that the permissible difference between the heights above sea level in the places where the seed is harvested and, in the area, where crops are created should not exceed 500–550 m.

B V Raevsky [8] analyzed the course of growth of 45 origins in geographical cultures of Scots pine in Karelia over a 30-year period, V P Makarov, VP Bobrinev [9] - cultures of Dahurian larch in the
Chita region, S N Tarkhanov [10] - Norway spruce crops in the Komi Republic, E N Nakvasina [11] - 20-25-year-old Scots pine crops in the European part of northern Russia, T V Bedritskaya [12] Scots pine in the Murmansk region. N A Kuzmina [13], T N Novikova [14] studied the growth of geographical cultures of Scots pine in the Krasnoyarsk forest-steppe.

According to S V Manzo et al. [15], in the geographical cultures of the Greg pine in Mexico, created in 1997, the interaction of the genotype with environmental conditions manifested itself in all growth parameters.

When studying the variability of the Siberian stone pine in geographical cultures in the Moscow region [16, 17], the Krasnoyarsk Territory [18, 19], a high polymorphism was noted in the offspring of the populations, and the best forms were identified. Nevertheless, the individual and geographic variability of Siberian cedar seed production in geographic cultures under specific forest conditions requires a long study period [20, 21, 22].

The purpose of the research is to study the variability of 56-year-old cedar of Siberian Altai and Tanzybei origin in terms of growth intensity and cone formation, growing on the site of the Siberian State University arboretum "Continuation of Geoschool" in the suburban area of Krasnoyarsk.

2. Objects and methods
The site and characteristics of the maternal populations used for collecting seeds with subsequent cultivation of offspring are shown in table 1.

| Republic, region, | N.L., ° | E.L., ° | Altitude above the sea level | Class | Forest type | Stocking composition |
|-------------------|---------|---------|-----------------------------|-------|-------------|---------------------|
| Altai, Karakokshinsk Timber Industry Enterprise (TIE) | 51°50' | 86°54' | 750 | III | herbal | 5SC3F2B |
| Krasnoyarsk, Tanzybei TIE | 53°30' | 92°25' | 500 | II | fern | 7SC2F1As |

In the place of growth, the maternal plantings differ insignificantly. They are included in the South Siberian mountain forest zone of the Altai-Sayan mountain-taiga region. The most productive is the plantation growing on the territory of the Tanzybei TIE (bonitet class II versus III in Karakokshinsk TIE).

The collection of seeds in these plantings was carried out in 1964, the transplantation of seedlings to the school department - in 1966, to the permanent place - in 1983 (planting scheme 4x4 m).

In the fall of 2019, biometric indicators were determined for the Siberian cedar at the age of 56 years old: height, trunk diameter at a height of 1.3 m, crown diameter, as well as the number of cones on the shoot, on the tree. Correlation analysis between the studied indicators was carried out. The specimens distinguished by intensive growth and increased productivity were identified. The research results were processed statistically using the Microsoft Office software package.

3. Results and discussion
The level of variability of growth indicators of Siberian cedar of different origin from medium to high was found (table 2).

| Geographical origin | $\bar{X}$ ±m | V, % | P, % | $t_0$ at $t_{05}$ = 2.04 |
|---------------------|------------|-----|-----|-----------------------|

Height, m

| Geographical origin | Tree number | Trunk diameter, cm | Crown diameter, m | Number of cones on a tree, pc. |
|---------------------|-------------|--------------------|-------------------|--------------------------------|
| Altai               | 68-4        | 31                 | 7.3               | 42                             |
|                     | 74-8        | 32                 | 6.8               | 38                             |
| Tanzybei            | 72-5        | 23.2               | 5.5               | 18.2                           |
|                     | 70-6        | 28                 | 7.0               | 69                             |
| Average value for the variant | 23.2 | 100.0 | 5.5 | 18.2 |
| Altai               | 25.2        | 17.5               | 5.5               | 42                             |
| Tanzybei            | 24.6        | 24.8               | 7.2               | 159                            |
| Average value for the variant | 24.6 | 100.0 | 5.0 | 32.6 |

The height and diameter of the trunk and crown have large indicators in the offspring of the Altai population, however, the difference between them is not confirmed statistically (t < 0.05).

All trees at the age of 56 have formed cones, however, there is a large difference in their number on a tree: in the Altai version - from 2 to 42 pcs., In the Tanzybei version - from 10 to 159 pcs.

The number of cones in a bunch (on the shoot) varies from 1 to 3 pcs. The largest number of three-cone trees (25.0%) was observed in trees of Tanzybei origin in comparison with Altai (16.7%).

The specimens were selected according to the intensity of growth and the formation of cones (table 3).

### Table 3. Trees with the highest growth rates and cone formation.

| Geographical origin | Tree number | Trunk diameter, cm | Crown diameter, m | Number of cones on a tree, pc. |
|---------------------|-------------|--------------------|-------------------|--------------------------------|
|                      |             | % to X             | % to X            | % to X                         |
| Altai               | 68-4        | 31                 | 7.3               | 42                             |
|                     | 74-8        | 32                 | 6.8               | 38                             |
| Tanzybei            | 72-5        | 23.2               | 5.5               | 18.2                           |
|                     | 70-6        | 28                 | 7.0               | 69                             |
|                      |             | 23.2               | 100.0             | 18.2                           |
|                      |             | 24.6               | 100.0             | 32.6                           |

The largest diameter of the trunk, crown and the number of cones are noted in trees with numbers 68-4, 74-8 of Altai and 72-5, 70-6 of Tanzybei origin. Their number of cones exceeded the average value by 2.1-4.9 times.

It should be noted that the selected trees 74-8, 72-5 and 70-6 belong to the multi-cone form (the maximum number of cones “in a bunch” is three). For tree 68-4 of Altai origin, the maximum number of cones on the shoot was 2 pcs.

Relationships were established between trunk diameter and height (r = 0.503; 0.556), trunk and crown diameter (0.530; 0.497), crown diameter and number of cones (0.726; 0.603) in trees of Altai and Tanzybei origins, respectively.

### 4. Conclusion

Trees 72-5 of Tanzybei origin and 68-4, 74-8 of Altai origin, which are recommended for reproduction by grafting and obtaining clone varieties with increased seed productivity, have the greatest breeding value. Trees which are characterized by growth intensity and yield have been selected for the purpose of the selective planting material cultivation.

### References

[1] Ivanov A V 2012 Seasonal growth of geographical spruce crops in the southern subzone of the taiga in 2009 Vestnik MGUL. Lesnoy Vestnik [EI] 1 57-9

[2] Milyutin L I and Terentyev V I 1999 Geographical cultures of spruce in the Krasnoyarsk Territory
Lesovedenie 4 16-23

[3] Redko G I and Dursin A D 1982 Geographical cultures of spruce (L.: LTA) p 60

[4] Hawrysz Zbigniew, Zwolinski Jozef, Kwapis Zygmunt and Matusczyszk I 2008 Rozwój różnych pochodzeń sosny zwyczajnej na pozarzysku w Nadlesnictwie Potrzebowice Les. pr. bad. 69(1) 57-65

[5] Raevsky B V 2011 Meteorological method for predicting the abundance of seed production in forest seed plantations of Scots pine Preservation of forest genetic resources of Siberia (Krasnoyarsk: IL SB RAS) p 121-2

[6] Cherepnin V L 1980 Variability of Scots pine seeds (Novosibirsk: Nauka) p 181

[7] Nikolaeva M A, Orlova L V, Krestyanov A A and Kamatov D N 2019 Geographic variability of larch in the experimental forest cultures of the Republic of Bashkortostan Siberian Forest Journal 1 30-43

[8] Raevsky B V 2012 Forecast of the yield of cones and seeds on forest seed plantations of Scots pine in Karelia Conifers of the boreal zone 30(1-2) 162-8

[9] Makarov V P and Bobriniov V P I 1997 Introduction of larch trees in Eastern Transbaikalia Flora, vegetation and plant resources of Transbaikalia. Chita 201-3

[10] Tarkhanov S N 1998 Variability of spruce in the geographical cultures of the Komi Republic (Yekaterinburg: Publishing house of the Ural Branch of the Russian Academy of Sciences) p 195

[11] Nakvasina E N 2003 Regularities of the geographical variability of Scots pine in experiments in the north-east of Russia Lesnoy Zhurnal 4 14-8

[12] Bedritskaya T V 2009 Testing the climatypes of Scots pine in the Murmansk region Bulletin of the Pomor University. Ser. Natural sciences 1 47-50

[13] Kuzmina N A 1999 Features of the growth of geographical crops of Scots pine in the Angara region Lesovedenie 4 23-9

[14] Novikova T N 2017 Study of the geographical cultures of Scots pine in the Krasnoyarsk forest-steppe in order to clarify the forest-seed zoning of this species Coniferous boreal zone XXXV 3-4 42-6

[15] Manzo Salvador Valencia 2006 Ensayo de procedencias de Pinus greggii Engelm. en dos localidades de la Mixteca Alta de Oaxaca, Mexico Rev. fitotecn. Tech. 29(1) 27-32

[16] Kozhenkova A A and Bryntsev V A 1991 Research of Siberian cedar of different geographical origin Scientific works of MLTI. Moscow 40-3

[17] Semaev S V 2010 Geographic cultures of Siberian cedar in the Dmitrovskoe forestry of the Moscow region Lesnoy Vestnik. MGUL Bulletin 3(72) 132-4

[18] Bratilova N P et al. 2015 Features of growth of Siberian cedar pine of different geographic origin Scientific practice of the Lisivnichy Academy of Sciences of Ukraine 13 59-63

[19] Kuznetsova G V 2010 Growth, condition and development of cedar pines in geographical cultures in the south of the Krasnoyarsk Territory Coniferous of boreal zone 27(1-2) 102-7

[20] Matveeva R N, Butorova O F and Shcherba Yu. E. 2011 Influence of geographical origin on the reproductive development of Siberian cedar on a forest seed plantation over a 24-year period Lesnoy Zhurnal 4 7-10

[21] Matveeva R N and Butorova F F 2007 Collection of cedar pines of different geographic origin at the experimental sites of the Siberian State Technical University (Krasnoyarsk: SibSTU) p 68

[22] Putenikhina K V, Shigapov Z Kh, Mkrtchyan M A and Putenikhin V P 2014 Quantitative indicators of Siberian cedar cones and seeds during introduction Coniferous of boreal zones XXXII(5-6) 59-64