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EVALUATION OF GROWTH VARIABILITY BY DIAMETER OF EUROPEAN SPRUCE TREES OF DIFFERENT ORIGIN IN A CHANGING CLIMATE

An assessment of the radial growth of various climatic ecotypes of European spruce growing on the territory of the Negorelsky educational and experimental forestry enterprise (Minsk region of Belarus) is given. A significant difference was revealed in the parameters of the average width of annual rings, as well as the proportion of early and late wood in the studied climatic ecotypes of European spruce. The years with the smallest radial growth of trees are noted, as well as the years with the maximum increase in tree diameter.

Numerous works have been devoted to the study of the influence of climatic and geographical factors on the adaptive capacity of coniferous species, including the assessment of the growth of climatic ecotypes of European spruce of various geographical origins [1–3].

The first geographical forest plantations of European spruce on the territory of Belarus were planted in the Negorelsky educational and experimental forestry enterprise in the spring of 1961 on an area of 0.5 hectares, geographically including six different growing regions - spruce of Minsk, Vitebsk, Grodno, Novgorod, Vologda and Ivano-Frankivsk origin.

The area allocated for geographical crops was an old clearing that emerged from under a spruce plantation. The soil in the area is soddy-podzolic, strongly podzolized, sandy loam on cohesive sandy loam, underlain by moraine loam, and from a depth of 180 cm by cohesive sand. The type of habitat conditions is C2. Three-year-old European spruce seedlings were used as planting material. Placement of seats on the entire plot 2.0 × 0.7 m, initial crop density – 7140 pcs/ha. Geographical cultures of European spruce on the site are arranged in sections and are limited by pillars and clearings for the purpose of their identification. The area of each climatic ecotype of European spruce is 0.08 ha.

To assess the growth and dendro-chronological analysis in each climatic ecotype of European spruce, a complete enumeration of trees was carried out, followed by the determination of all forestry and taxation indicators. Subsequently, cores were taken from five medium trees of each climatic ecotype at chest level (1.3 m) for the

subsequent determination of the value of the radial growth of trees of the various origins of European spruce under study. Wood core samples were taken with the help of Pressler borer. Subsequently, they were prepared for measurement and cleaned, photographed in relation to scale using a ruler, the growth rings of wood were measured in Photoshop 7.0, followed by further statistical processing of the obtained data and their analysis.

Geographical cultures of European spruce, including various origins of European spruce, differ from each other in climatic indicators of the places where mother trees grow.

The results of the study show that European spruce trees of Grodno origin are characterized by the largest radial growth, and the minimum increase in diameter is characteristic of European spruce trees of Ivano-Frankivsk origin (Table 1).

Table 1

Radial growth rates of European spruce

European spruce climatype name	Average annual ring width, mm	Average width of early wood, mm	Average latewood width, mm	Share of late wood, %
Minsk	2,02±0,07	1,38±0,05	0,64±0,01	32,1
Vitebsk	2,42±0,07	1,83±0,07	0,59±0,01	26,5
Novgorod	1,95±0,05	1,40±0,04	0,56±0,02	30,0
Vologda	2,22±0,06	1,37±0,05	0,86±0,02	40,3
Ivano-Frankivsk	1,80±0,05	1,21±0,04	0,58±0,02	34,3
Grodno	2,71±0,07	1,96±0,07	0,76±0,02	28,7

According to the share of late wood, spruces of Vologda origin are the most significant, the minimum share of late wood is noted in spruces of Grodno and Vitebsk origins.

According to the average width of the annual layer of wood, all the studied origins at a statistically significant level differ from each other, with the exception of the compared pair of European spruce of Minsk and Novgorod origins (Table 2).

Analyzing the change in radial growth over the years from 1970 to 2021, it was noted that in all origins of European spruce, starting from the mid-eighties of the last century, there has been a sharp decrease in the radial growth of trees.

Table 2

Criteria for the significance of differences in the width of the annual layer wood from different origins of European spruce in geographical forest plantations

Climatype	Grodno	Vitebsk	Vologda	Minsk	Novgorod	Ivano-Frankivsk
Grodno	–	–	–	–	–	–
Vitebsk	2,37	–	–	–	–	–
Vologda	4,53	2,34	–	–	–	–
Minsk	6,05	4,24	2,17	–	–	–
Novgorod	7,38	5,7	3,46	0,81	–	–
Ivano-Frankivsk	8,84	7,44	5,38	2,56	2,12	–

In European spruce of Grodno origin, the maximum radial growth was observed from 1977 to 1993. Since 1995, there has been a sharp decline in radial growth. The years with minimal growth were noted: 1973, 1974 and 2021, when the growth in tree diameter was less than 1 mm. The share of late wood of trees of Grodno origin averages 28.7%. In this case, the increase in diameter is mainly formed due to early wood in the spring-summer period from May to June.

In European spruce of Vitebsk and Minsk origins, a similar pattern is observed in the dynamics of growth in diameter. Thus, in spruce of Vitebsk origin, the maximum radial growth is observed in the period from 1975 to 1988, and the years with the minimum growth are 1974, 2015 and 2021. The share of late wood in trees is minimal and amounts to only 26.5%. In the European spruce of Minsk origin, the maximum increase in diameter was in the period from 1976 to 1988, and the years with the minimum increase were 1974, 1975, 2020 and 2021, and a rather sharp decrease in growth has been observed since 1995.

European spruce trees of northern origin also show a decrease in growth in diameter, starting from the 90s of the last century, however, this decrease is more gradual and, unlike European spruce of local origin, there is no sharp decrease in growth in the 70s of 20th century. European spruce of Vologda origin has the highest proportion of late wood, and in years with a higher increase in diameter, the proportion of late wood was equal to or exceeded the proportion of early wood (1993–1995).

European spruce of Ivano-Frankivsk origin is characterized by the smallest radial growth. The maximum increase is noted from 1978 to 1987, and starting from

1988, there is a sharp decrease in the increase in diameter in trees. The smallest increase in diameter (less than 1 mm) is characterized by 1970, 1997 and 2019.

An analysis of the increase in diameter in European spruce of various origins showed that the sharpest decrease in radial growth in the first decade is observed in trees of Minsk (45.8%) and Ivano-Frankivsk (36.4%) origins (Table 3).

Table 3

Changes in the width of the annual layer in European spruce trees of various geographical origins for the periods under study

European spruce climatype name	Decrease in radial increment, % for 1970–2021	Annual layer width by periods, mm			
		1970–1985	1986–1997	1998–2007	2008–2021
Minsk	59,8	3,01	1,63	1,50	1,21
Vitebsk	56,3	3,41	2,98	1,83	1,49
Novgorod	49,8	2,67	2,16	1,70	1,34
Vologda	53,0	3,15	2,27	1,76	1,48
Ivano-Frankivsk	52,5	2,72	1,73	1,49	1,29
Grodno	50,4	3,61	3,40	2,04	1,79

Between 1970 and 1985 the average width of the annual ring in spruce of Minsk origin is 3.01 mm; from 1986 to 1997 increase in diameter went down by 45.8%. For spruce of Ivano-Frankivsk origin, the initial reduction in radial growth was 36.6%. European spruce of Grodno origin in this period showed the best results - the radial growth of trees decreased only by 5.8%.

For the period from 2008 to 2021 the largest decrease in radial growth is observed in European spruce trees of northern origin (spruce of Novgorod origin by 21.2%, Vitebsk origin by 18.6%, and Vologda origin by 15.9%). In European spruce trees of Minsk and Grodno origins, the decrease in growth in tree diameter is 12.4 and 12.3%, respectively.

In general, for the entire analyzed period of observations, the decrease in radial growth in European spruce trees of various origins is 49.8–59.8% (the maximum decrease in diameter growth in European spruce trees of Minsk origin is 59.8%, the minimum decrease in growth in diameter in trees of European spruce of Novgorod origin - 49.8%). The conducted studies of the radial growth of European spruce of various origins made it possible to identify not only the existing difference in the total width of the annual layer in the trees under study, but also in the share of participation

in the annual ring of early and late wood, as well as various levels of decrease in growth in diameter in the studied origins of spruce growing in geographic forest cultures.

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