

# Research Journal of Pharmaceutical, Biological and Chemical Sciences

## Peculiarities of Seeding of Species of the Genus *Picea* in the Urban Plantations (by way of the example of the city of Izhevsk).

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### ABSTRACT

Seeding of woody plants is determined by a number of factors, including external environmental conditions, in which the seed is formed. The reproductive potential of any living organism is one of the most important indicators of the organism's adaptation to environmental conditions. For the purpose of evaluating the reproductive ability of conifers growing in the cities, the parameters of spruce cones and qualitative variables of seeds (specific gravity, number of seeds per strobile, seed weight, germinative energy and technical germinability) have been studied in two species: the local species of common spruce (*Picea abies* L.) and the alien species of blue spruce (*Picea pungens*).

**Keywords:** conifers, seeding, specific weight of seeds, germinative energy, technical germinability.

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## INTRODUCTION

Fir tree plantations are dominant in frigid and temperate zone of the Northern hemisphere, where they form the landscape of the European taiga. However, the active economic activity has led to a change of the primary spruce systems into the secondary ones, where the deciduous species (aspen, birch, willow, and others) begin to play the role of forest-forming species. Thus, direct and indirect anthropogenic impact on the forests results in the change of the bedrocks and reduction of fir formations, despite active homogeneous forest standing [18, 22]. In this connection, much attention is devoted to the study of gymnosperms of the boreal region.

Though the study of the features of seeding of conifers has been conducted for a long time, the research in this area in species growing in the urban and suburban areas are rather rare.

It should be noted that some alien species of coniferous plants have high points of life state in the urban areas and are the objects of study of features of forming adaptive reactions to the conditions of technogeneous environment. These species include blue spruce (*Picea pungens* Engelm.) [12,13,16,20]. In this species in the urban plantations, an abundance of cones and seeds which could become a source of inoculum for specialized seed plots is formed. But we have not found out the information about the quality of such seed material of this species being formed under the conditions of anthropogenic load.

The objective of the research is a comparative study of seed production of blue spruce (*Picea pungens*) and common spruce (*Picea abies* L.) under the conditions of anthropogenic load.

The studies were conducted in the city of Izhevsk, situated in the central part of the Republic of Udmurtiya, which is exposed in the northern half of the temperate zone. Izhevsk is located at the border of two regions of the forest zone - the South taiga region and coniferous and broad-leaved forests of the European part of Russia [9].

The climate of the city is characterized as a temperate continental with long winters being rich in snowfalls. There is a dominance of the southwest winds with average annual speed - 4 m / sec. The average annual temperature is +2,4 ° C.

Annual precipitation in the city amounts in the mean to 508 mm (sufficient watering) but is unstable through its uneven distribution over months and seasons of the year [4]. On the basis of the library materials of the Udmurt center of Hydrometeorology and Environmental Monitoring (UCHEM), the index of air pollution (API) according to the five priority pollutants (carbon oxide, nitrogen dioxide, formaldehyde, benzopyrene, suspensions) (Table 1) was calculated for each area under study.

**Table 1. The values of the complex atmospheric pollution index (API) and the overall pollution index of soils (OPI) in Izhevsk**

The area under exploration	API	OPI
Zone of conditional monitoring		
S.M. Kirov Central Park	5.21–3.1	8–16
The main road		
Utmurtskaya Street	11.91–9.35	32–128
Residential area		
Housing estate «North»	5.21-6.50	16-32

The soils in parkland (conditional zone control) are characterized by a low level of contamination (the total index of soil contamination is used) that is calculated as the sum of concentration factors, i. e. the sum of the content of each element in the test soil to the background concentration. The level of soil pollution in the plantations of the residential area is assessed as moderately dangerous, and in the forests along the main road - as dangerous (Table 1).

## MATERIALS AND METHODS

The studies were conducted in the plantations of different ecological categories, arranged in view of the functional zoning of the city and being subject to anthropogenic load of different intensity: plantations of residential areas (housing estate «North») and the plantations along the main road (Utmurtskaya Street). According to the methodological approaches [7], the park of landscape type – the Central Park named after S. M. Kirov which has an area of 90 hectares and undifferentiated compact configuration was chosen as a conditional control zone (CCZ). The test plots (0.25 ha) with account plants (three specimens of each species) to be selected and numbered were laid in each planting. Account specimens had a good life condition and average generative ontogenetic state.

The objects of study were species of woody plants of the genus *Picea* - representative of the local flora - common spruce (*Picea abies* L.) and strange blue spruce (*Picea pungens* Engelm.).

The applied methods of determining the quality of seeds and seeding indices are described in the works by A. I. Novoseltseva [10], A. A. Molchanova [8] and in SS 13056.6-97 [5].

The weight of spruce cones and seeds was determined on the electronic balance to 0.001 g. The linear parameters of spruce cones (length and diameter) were measured by using the caliper to the nearest 0.1 cm.

To measure qualitative variables of the seeds, one determined specific gravity, technical germinability and germinative energy of seeds [5]. The specific gravity of seeds is understood as mass of volume unit that depends on the density, chemical composition and seed maturity. The difference in the specific gravity is used for cleaning seeds from the seeds of weed vegetation, and for selecting biologically more valuable heavy-weight seeds.

We used the method of hydrostatic weighing, based on Archimedes principle. The volume of seeds was determined by means of hydrostatic weighing (on an analytical balance «Tur WA-21»). Specific gravity of the seeds was calculated as the ratio of the weight of the dry seeds to their volume.

Before laying the seeds to determine technical germinability and germinative energy, they were stratified. We applied the most widely used method of thermal stratification (low positive temperatures). The seeds were washed with warm running water and then held in a swollen state in a moist and well aerated environment at the temperature of + 5 °C for two months. Seed stratification was carried out in cloth (gauze) bags. The calcined band sand was used as a substrate. To prevent infection of seeds, before laying for stratification, they were treated with a potassium permanganate (KMnO<sub>4</sub>) solution of 0.01% for 12 hours [8].

The mathematical processing of the results was carried out by means statistical software package «Statistica 6.0», by applying the methods of cluster analysis and descriptive statistics.

## RESULTS

We processed the primary data array using the cluster analysis, which allows to distribute all the studied parameters and objects in the cluster (s) according to the set of common features (Figures 1, 2).

Based on the cluster analysis of the totality of the studied parameters, two clusters (distance 100%) have been differentiated, in one of which the factor of seed quantity in spruce cone is highlighted, in the other - all other parameters (Figure 1). Based on the cluster analysis of the studied species of plants in different types of growth, one also differentiates two large clusters (Figure 2). In one of them a blue spruce which grows in a residential area is represented, in the second – both of the studied species in all other types of growth.

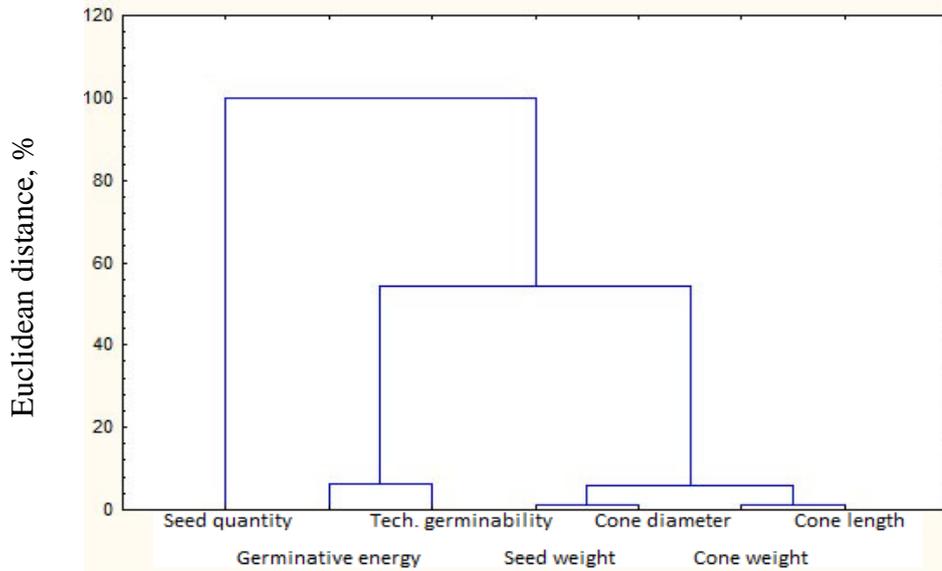


Figure 1 – Cluster Analysis of the Studied Parameters

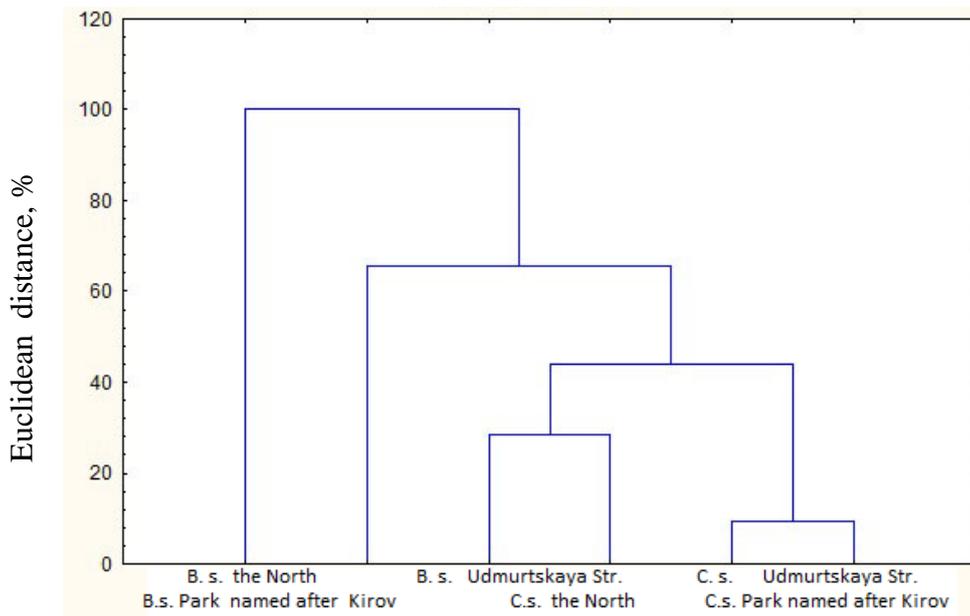


Figure 2 – Cluster Analysis of the Studied Species

Note: B.s. – Blue spruce, C.s. – Common spruce.

To compare the features of seed production of the studied species with figures in a park area, we used the methods of descriptive statistics (Table 2).

As a result, it has been found that blue spruce in all the types of urban plantations has the indices of specific seed weight significantly lower than the specific weight of seeds of common spruce, however, according to this characteristic, significant differences in specimens that grow in different types of growth, in both species, have not been found.

It should be observed that the specific gravity of seeds in the park zone is lower than in the forests along the main road and residential area, although there are no statistically significant differences.

It should be noted that the technical germinability and germinative energy of seeds in specimens of blue spruce in the park area had zero values. However, in the growth of the main road and residential areas, these values ranged from 24 to 74% and had a statistically significant difference from the control values (Table 2). The highest values were observed in the plantations of the residential area. Although the germinative energy of seeds was 70% in the residential area and 24% in the zone of along the main road, but on the 4th day after seed germination, it was observed single loss of seedlings, which ended with their mass desiccation on the 7th day.

Besides qualitative seeds, the morphological characteristics of female strobiles of the studied species of spruces were analyzed. The most variable feature proved to be the length of strobile. In the main roadside plantations it was significantly higher in blue spruce than in the specimens of park and residential plantations by 1,7 and 1,38 cm, respectively. The other parameters of strobiles (weight and diameter) in specimens of both species in different types of plantations had no significant differences from the zone of nominal control.

In our view, the external factors affect the size (length) of the strobiles in the plants of the main roadside forests. According to the researches by a number of authors who have studied the features of the formation of the organs of fruitification in blue spruce, we have found that this parameter has variability in different climatic zones ranging from 5 to 19 cm [1-3, 11]. It is noted at the same time that in the conditions of drier climate, the length of spruce cones increases, although in the conditions of natural area, the length of strobiles in blue spruce accounts for 6-10 cm. All the authors note that the value of the cone diameter is less variable and does not exceed 2-3 cm in any growing conditions, which we have seen in the ongoing studies [6, 14, 15, 17, 19, 21].

The results of evaluation of the reproductive ability of species of common spruce growing in different types of plantations have showed no significant differences from the zone of a conditional control according to a number of parameters. The indicators of seed germinative energy in plantations of the city are higher than in the plantations of the park zone: by 19% in the residential area and by 15% in the main stands. The low germinative energy of the seed in the species growing in the parkland, may be conditioned by older age of plantations (the age of class - overripe) and the mass spread of bark-beetles, observed there in recent years. The factors of coming of the seeds up, specific gravity and weight of the seeds are within the average values for this type and had no significant differences with CCZ [8].

At the same time, in urban plantations, the quality indices of the seeds (specific gravity of seed, technical germinability) in Norway spruce had no significant differences from the parkland plantations, but had higher germinative energy, and these differences were statistically valid as compared with the CCZ.

#### SUMMARY

These experiments allowed to evaluate the reproductive capacity of coniferous species in the urban environment, to identify the characteristics of their reactions to the growing conditions, to conduct a comparative analysis of the studied species and determine their characteristics in terms of urban environment.

As a result, it has been established that the index of the specific gravity of the seeds in Colorado spruce in all types of urban plantations is less than the specific gravity of the seeds of Norway spruce. Technical germination and germinative energy in the park zone had zero values, and in the stands of the road and residential zones, the figures were 24-74%, respectively. Despite the high rate of germinative energy, in the experiment, mass loss of seedlings by the end of the calendar week was observed.

The linear parameters of the strobiles of blue spruce turned out to be the most variable – that is, the length of strobile. In the main roadside plantations, it was significantly higher than that in the specimens of the plantations of the park and residential zones by 1,7 and 1,38 cm, respectively.

The analysis of the results of the reproductive capacity of Norway spruce, which grows in different types of plantations according to most of the studied parameters, revealed no significant differences from the conditional control zone, except germinative energy of the seeds, which was higher in the plantations of the city, compared with the plantations in the CCZ. Such parameters as the coming of the seeds, their specific

gravity and weight had no significant differences in the different types of plantations of the city quantitatively were within the average values for the species.

The study was financially supported by the RFBR in the framework of research project № 14-04-31909

**Table 2.** Morphometric characteristic of generative organs of conifers (Izhevsk, 2014)

Species	Length of strobile, cm	Diameter of strobile, cm	Strobile weight, g	Number of seeds in strobile	Mass of seeds in a strobile, g	Specific gravity, $\frac{g}{cm^3}$	Technical germinability, %	Germinative energy, %
The Central park named after S.M.Kirov								
Common spruce (Norway)	7,70±1,56	2,71±0,38	5,73±1,36	100,50±17,40	0,53±0,09	0,59±0,007	46,00±16,00	20,00±2,00
	6,58...8,82*	2,44...2,98	4,76...6,70	88,05...112,95	0,46...0,59	0,53...0,66	30,00...62,00	18,00...22,00
Blue spruce (Colorado)	7,25±0,86	2,98±0,35	6,72±0,93	113,60±12,98	0,38±0,04	0,17±0,01	0	0
	7,34...7,74	2,73...3,23	6,05...7,38	104,31...122,89	0,35...0,42	0,04...0,30	0	0
The Housing Estate «The North»								
Common spruce	7,80±0,87	2,00±0,27	9,31±2,81	140,67±64,08	0,35±0,16	0,58±0,007	61,00±11,00	39,00±1,00
	5,65...9,95	1,34...2,66	2,34...16,28	-18,52...299,85	-0,05...0,74	0,51...0,64	50,00...72,00	38,00...40,00
Blue spruce	7,57±0,21	2,23±0,21	9,73±2,74	180,67±95,63	0,34±0,22	0,35±0,06	74,00±8,00	70,00±10,00
	7,05...7,08	1,72...2,75	2,92...16,53	-56,89...418,23	-0,21...0,88	-0,16...0,46	66,00...82,00	60,00...80,00
Udmurtskaya Street								
Common spruce	8,14±0,57	2,90±0,31	6,18±0,69	102,30±15,85	0,53±0,08	0,57±0,007	54,00±2,00	35,00±7,00
	7,74...8,54	2,65...3,12	5,69...6,67	90,96...113,64	0,47...0,59	0,50...0,63	52,00...56,00	28,00...42,00
Blue spruce	8,95±1,67	3,15±0,38	7,24±1,15	123,80±16,38	0,44±0,06	0,40±0,08	30,00±22,00	24,00±16,00
	7,75...10,15	2,88...3,42	6,41...8,06	112,08...135,52	0,39...0,48	-0,36...0,49	8,00...52,00	8,00...40,00

**Note\*** the interval for average value at  $P \leq 0,05$ ; the results having significant difference with the control are in bold type

Blue spruce in the plantations of the main road and residential zone had significant differences from the CCZ on a number of parameters: the length of cones in the species of main road plantations was higher, and of residential zone, vice versa, significantly lower than of the park plantations; the indices of technical germinability and germinative energy of the seeds in the species of urban plantations exceed the indices of the CCZ.

Norway spruce and Colorado spruce on the majority of generative parameters are not distinguished significantly in comparison with each other.

### CONCLUSION

Seeding of vegetable organism depends on the biological characteristics of the individual and the external environment conditions, which are interrelated and influence each other. The study of the reproductive potential in the urban conditions of two types of coniferous plants has revealed that the majority of the studied parameters the common spruce and the blue spruce do not have significant differences. However, such indices as the specific weight of seeds, linear parameters of the strobiles (in blue spruce), the germinative energy of the seeds (in common spruce) showed species specificity and reaction to the growing conditions.

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