The effect of seed thickness alignment on the uniformity of planting materia

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Abstract. The results of studies on the effect of calibration of Scots pine (Pinus sylvestris) seeds by size (thickness) on the yield of standard seedlings are presented in order to assess the effect of the lattice-free technology of calibration of scots pine seeds on the yield of standard seedlings when growing them in a nursery. The seed batch of scots pine before sowing was calibrated on an experimental sample of a lattice-free separator in size (thickness). The size gap in the fractions was determined experimentally using end measures and an electronic caliper, based on the minimum and maximum sizes (thickness) of the seeds. As a result, two fractions of seeds were obtained. The resulting seed fractions were sown on nursery areas. Uncalibrated seeds were used as a control. It was found that the highest yield of standard seedlings (94-98%) was observed when using calibrated seeds regardless of the fraction. When sowing with uncalibrated seeds, the yield of standard seedlings was only 64-79%. The height of seedlings grown from uncalibrated seeds varied from 5 to 32 cm, calibrated (large fraction) – from 13 to 23 cm, calibrated (small fraction) – 10 to 13 cm. The diameter of the root neck in crops with uncalibrated seeds varied from 1.86 mm to 11.94 mm, calibrated large seeds – from 3.88 to 4.56 mm, calibrated small seeds – from 2.99 to 3.41 mm.

1 Introduction

Modern forestry is experiencing greater needs for seed and planting material than before. A decrease in the volume of harvesting seeds of the main forest-forming conifers exacerbates the problem of obtaining the necessary amount of planting material. Obtaining high-quality coniferous seeds (scots pine, scots spruce, etc.) is impossible without the use of such technological operations as de-spraying, cleaning, sorting (calibration), etc.

Sizing is the most important final stage of the entire technological process of processing forest seed material, since as a result, fractions of aligned seeds are obtained. This, in turn, makes it possible to differentiate the seeding rate depending on their size, contributes to the rational use of seed material and significantly increases the yield of standard seedlings per unit area of the nursery. Sizing seeds by size is one of the methods of achieving uniformity

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of sowing, obtaining more seedlings per unit weight of seeds and reducing competition between them [10].

Information about the relationship between the physical properties of coniferous seeds is important for the formation and modeling of cleaning, sorting, storage, sowing and processing of seeds [19,21]. The viability of seeds and the energy of their germination are the main factors determining the quality of seeds [21]. According to many authors, the germination energy correlates with the weight of the seed. At the same time, the growth and development of seedlings grown from large seeds is not always more effective than the growth and development of seedlings grown from small seeds. [6,10,15-18,20].

In order to ensure uniformity in the germination of seeds of different sizes, various technological techniques are used and, in particular, size calibration. This makes it possible to equalize the parameters of seedlings by selecting opportunities for seed growth and development [8]. Plants grown from sorted seeds are more aligned and characterized by similar morphological parameters. Sorting is possible using vibratory and vibro-pneumatic separators [19] only if the seeds differ in size but have the same mass, or if they differ in weight but have the same dimensions. However, the above-mentioned sorting machines do not have a positive effect due to a number of technological limitations when sorting coniferous seeds. To improve the quality of seed sorting, it is necessary to take into account the morphological relationship of the sowing qualities with the weight of 1000 pieces of seeds.

In the course of studies to assess the variability of the basic physical properties of seeds of some species of spruce and to identify correlations between these indicators, it was found that there is a close relationship between the weight of seeds and their thickness. Therefore, the thickness of the seed is the most reliable parameter for separating spruce seeds during sorting. It follows from this that spruce seeds must be sorted using sieves with longitudinal holes. The process of separating seeds by their thickness allows to obtain fractions that differ in the content of parenchymal tissue. The germination rate and germination of seeds can be increased if these fractions are sown separately from each other [12].

It should be noted that the common spruce (Pícea ábies) and the common pine (Pínus sylvéstris) have similar geometric sizes of seeds and therefore sieves with the same working hole sizes can be used for sorting (sizing) [1].

Analyzing the operation of existing machines and devices for sorting coniferous seeds by size, it is necessary to note their common disadvantage, which is that the holes of the sieves are clogged with seeds. Exploratory experimental studies have shown that the operation of a cylindrical sieve for 10 ... 15 minutes, 20 ... 25% is clogged, and a flat sieve up to 40% of its working surface. As a result, the productivity of the sieve and the machine as a whole decreases, the process of seed separation is disrupted, one fraction is mixed with another [1].

Therefore, when sorting using sieves, only the purification of coniferous seeds from impurities and waste actually takes place, but not their calibration. As a result, the seeds are sown with a common mixture without a clear separation by fractions. In our opinion, this leads to the fact that a larger number of grown seedlings (from 20 to 40%) either do not reach the standard size, or exceed it several times.

It should be noted that the thickness of coniferous seeds (Scots pine, scots spruce) is the most reliable criterion for selecting the most viable seeds [11-14].

Obtaining standard seedlings from coniferous seeds when growing them in forest nurseries is one of the main tasks of forestry. In this regard, the purpose of the research was to assess the effect of the lattice-free technology of calibration of Scots pine seeds on the yield of standard seedlings when growing them in a nursery.

2 Materials and methods

Voronezh State University of Forestry and Technologies named after G. F. Morozov has been working for a long time and consistently to solve the problems of effective restoration of green spaces. Over the past few years, according to a program developed by leading experts in this area, a number of scientific and production experiments have been conducted on the territory of the forest nursery of the state autonomous institution "Donskoy forestry" of the Lipetsk region (geographical coordinates of the nursery: latitude N 520 38.123' longitude E 380 59.101') to increase the productivity of the areas of the forest nursery when growing seedlings of scots pine.

The research was conducted in 2019-2020. The object of research is seedlings of Scots pine grown from seeds pre–calibrated in size (thickness). The seeds of the 2017 harvest were used for the research (Table 1).

Table 1. Characteristics of the seeds of scots pine

Seed thickness, mm		Seed weight, g		Purity, %	Germination, %	Year of collection
min	max	1000 pc.	parties			
1.1	2.1	8.1	32000	96	84	2017

The calibration of Scots pine seeds in size (thickness) was carried out on an experimental sample of a lattice-free separator [2-5]. The seed batch of scots pine before sowing was calibrated on an experimental sample of a lattice-free separator in size (thickness). The size gap in the fractions was determined experimentally using end measures and an electronic caliper, based on the minimum and maximum sizes (thickness) of the seeds. As a result, two fractions of seeds were obtained. The resulting seed fractions were sown on nursery areas. Uncalibrated seeds were used as a control. Sowing was carried out in the second decade of April in a narrow-line method. At the end of the second growing season of the growth and development of seedlings of scots pine, four accounting sites with a length of 1 m were allocated in all variants.

3 Results and discussion

In the course of the conducted research, at the end of the second growing season, standard and non-standard seedlings were accounted for at each accounting site. It was found that in crops with uncalibrated seeds, the number of plants in the accounting sites was: 228 pcs. – in the first site, 213 pcs. – in the second site, 297 pcs. – in the third site and 249 pcs. – in the fourth site (Table.2).

The number of non–standard seedlings in these plots was: in the first plot – 69 pieces (30.3%), in the second – 73 pieces (34.3%), in the third – 70 pieces (23.6%), in the fourth - 89 pieces (35.7%). Thus, the number of non-standard seedlings in experimental plots ranges from 23.6 to 35.7%. When planting, non-standard seedlings are discarded. Therefore, when growing seedlings from uncalibrated seeds, about 30% of the resulting seedlings are not used for planting in forest crops. At the accounting sites where sowing was carried out with large calibrated seeds, the number of plants was: 256 pcs. – in the first, 271 pcs. – in the second, 241 pcs. – in the third, 277 pcs. – in the fourth (Table 2).

Table 2. The number of seedlings of scots pine depending on the fraction of sown seeds

Seed fraction	№ sites	Number of seedlings				
		in total, pcs/square	standard		Not standard	
			pcs/square	%	pcs/square	%
Uncalibrated	1	228	159	69.7	69	30.3

	2	213	140	65.7	73	34.3
	3	297	227	76.4	70	23.6
	4	249	160	64.3	89	35.7
	Total	**987**	**686**	**69.0**	**301**	**31.0**
Calibrated seeds (large fraction)	1	256	243	94.9	13	5.1
	2	271	263	97.0	8	3.0
	3	241	237	98.3	4	1.7
	4	277	272	98.2	5	1.8
	Total	**1045**	**1015**	**97.1**	**30**	**2.9**
Calibrated seeds (fine fraction)	1	174	169	97.1	5	2.9
	2	197	189	95.9	8	4.1
	3	193	190	98.4	3	1.6
	4	139	135	97.1	4	2.9
	Total	**703**	**683**	**97.2**	**20**	**2.8**

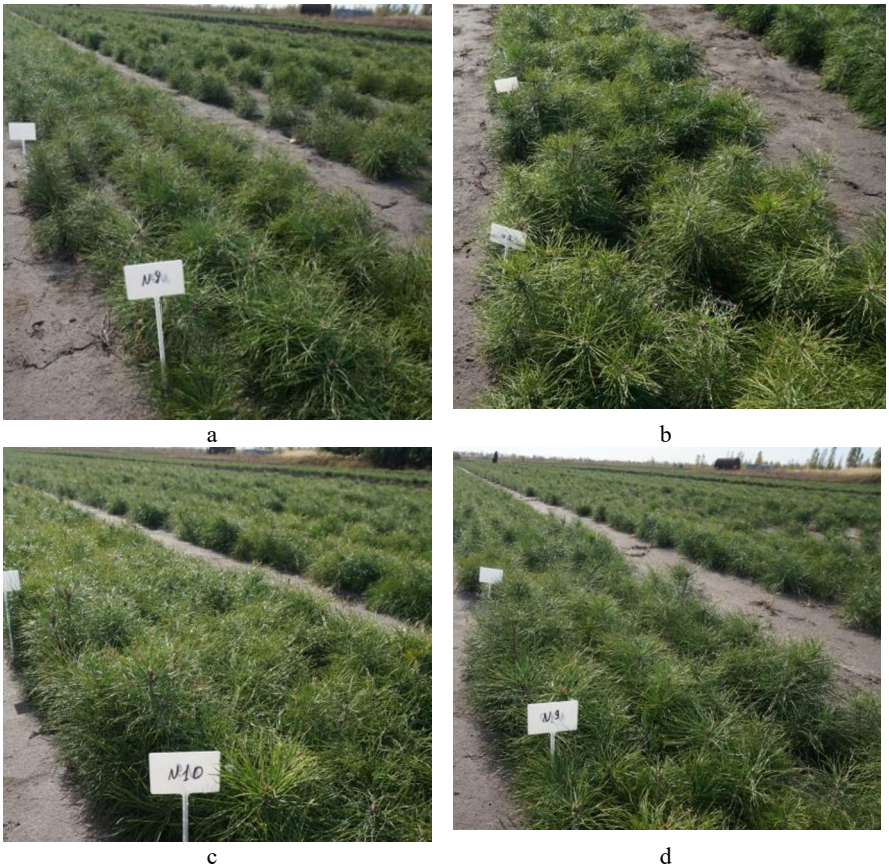
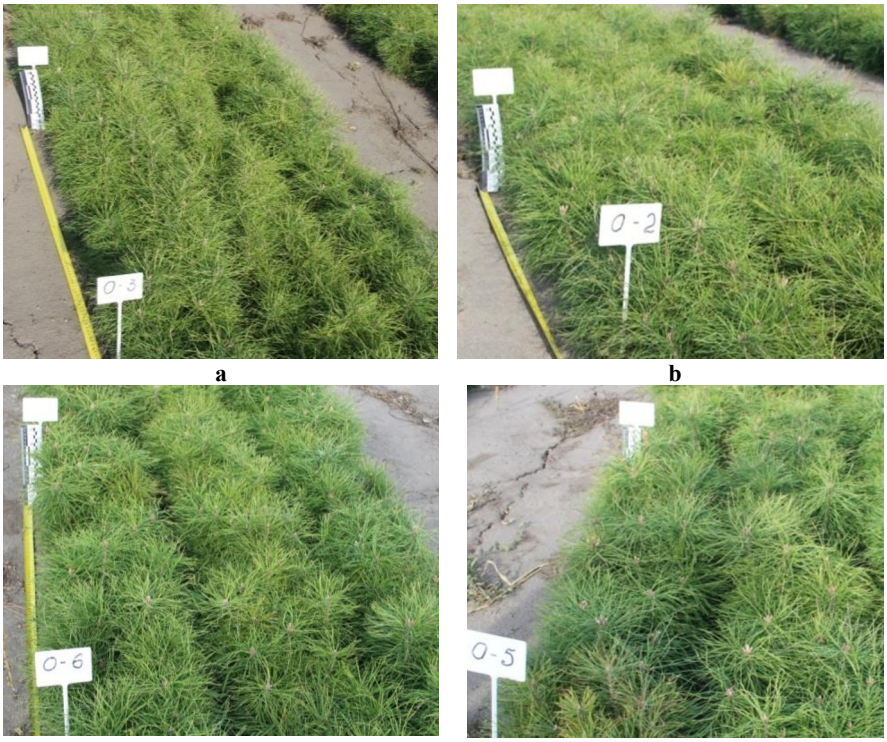


Fig. 1. Seedlings grown from uncalibrated seeds of scots pine: a – accounting platform No. 1; b – accounting platform No. 2; c – accounting platform No. 3; d – accounting platform No. 4



a **b**

c **d**

Fig. 2. Seedlings grown from calibrated large seeds of scots pine: a – accounting site No. 1; b – accounting site No. 2; c – accounting site No. 3; d – accounting site No. 4

The number of non–standard seedlings at these sites was: 13 pcs. (5.1%) – in the first, 8 pcs. (3.0%) – in the second, 4 pcs. (1.7%) - in the third, 5 pcs. (1.8%) – in the fourth.

From the data obtained, it can be seen that the number of non-standard seedlings in the accounting sites with calibrated large seeds is insignificant and varies from about 1.7 to 5.1%, which is an average of 2.9%.

Consequently, when using calibrated seeds of a large fraction, there is practically no loss of seedlings. At the sites where sowing was carried out with small calibrated seeds, the number of plants was: 174 pcs. – in the first; 197 pcs. – in the second, 193 pcs. – in the third, 139 pcs. – in the fourth sites (Fig. 3).

a **b**

c **d**

Fig. 3. Seedlings grown from calibrated small seeds of Scots pine: a – accounting platform No. 1; b – accounting platform No. 2; c – accounting platform No. 3; d – accounting platform No. 4

The number of non–standard seedlings in the accounting sites was: 5 pcs. (2.9%) – in the first, 8 pcs. (4.1%) – in the second, 3 pcs. (1.6%) - in the third, 4 pcs. (2.9%) – in the fourth. On average, for this variant of the experiment, the yield of standard seedlings was 97.2%.

According to the results of the analysis of variance, it was found that the studied factor (a variant of seed calibration) had a significant effect on the yield of seedlings, including standard and non-standard ones (Table 3).

Table 3. Assessment of the influence of the studied factor on the yield of seedlings of Scots pine per unit area of sowing (according to the data of dispersion analysis)

Indicator	SS	p
Seedling yield, total	16748.7	0.00
Output of standard seedlings	18206.2	0.00
Output of non-standard seedlings	12708.5	0.00

Note. The magnitude of the significance level $p<0.5$ indicates a significant influence of the factor

At the same time, in terms of the number of seedlings obtained, a significant difference was noted only between the variants using calibrated seeds of different sizes (Table 4).

Table 4. Assessment of the reliability of differences between the variants of the experience using the Fisher LSD (less significance distance) indicator

Option		1	2	3
Seedlings yield per unit area, total				
1	Uncalibrated seeds		0.48	0.01
2	Calibrated seeds (large fraction)	0.48		0.00
3	Calibrated (fine fraction)	0.01	0.00	
	Output of standard seedlings per unit area			
1	Uncalibrated seeds		0.00	0.97
2	Calibrated seeds (large fraction)	0.00		0.00
3	Calibrated (fine fraction)	0.97	0.00	
	The output of non-standard seedlings per unit area			
1	Uncalibrated seeds		0.00	0.00
2	Calibrated seeds (large fraction)	0.00		0.57
3	Calibrated (fine fraction)	0.00	0.57	

Note. The magnitude of the significance level $p<0.5$ indicates a significant difference between the variants of the experiment

The yield of standard seedlings was significantly high when using calibrated seeds of a large fraction. During the measurement process, seedlings with maximum, average and minimum root neck diameters characteristic of plants growing in each experimental sowing were selected from each accounting site (Fig. 4, 5, 6).

a b c

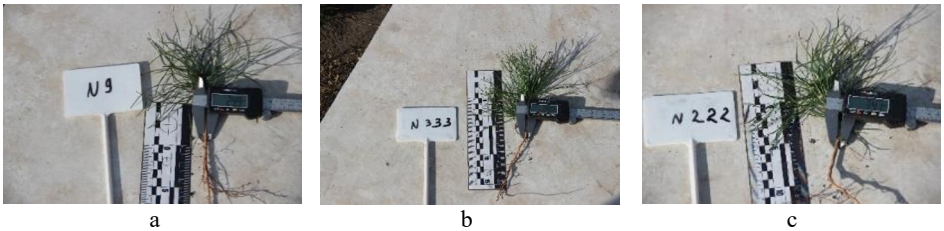
Fig. 4. Seedlings grown from uncalibrated scots pine seeds: a – minimum diameter of the root neck; b – average diameter of the root neck; c – maximum diameter of the root neck

At the same time, the height of plants obtained from uncalibrated seeds varied from 5 to 32 cm (Fig.4).

a b c

Fig. 5. Seedlings grown from calibrated large seeds of Scots pine: a – minimum diameter of the root neck; b – average diameter of the root neck; c – maximum diameter of the root neck

The height of seedlings grown from calibrated large seeds varied from 13 to 23 cm (Fig. 5).



a b c

Fig. 6. Seedlings grown from calibrated small seeds of Scots pine: a – minimum diameter of the root neck; b – average diameter of the root neck; c – maximum diameter of the root neck

At the same time, the height of seedlings grown from small calibrated seeds varied from 10 to 13 cm (Fig.6).

It was found that the variation in the diameter of the root neck in crops with uncalibrated seeds varies from 1.86 mm to 11.94, in calibrated large seeds – from 3.88 to 4.56 mm, calibrated small seeds – from 2.99 to 3.41 mm.

4 Conclusion

1. The highest yield of standard seedlings (94-98%) was noted when using calibrated seeds, regardless of the fraction. When sowing with uncalibrated seeds, the yield of standard seedlings was only 64-79%.
2. Seedlings obtained from seeds that had not been calibrated were less equalized. Their height ranged from 5 to 32 cm. The seedlings grown from calibrated seeds of a small fraction, whose height varied from 10 to 13 cm, turned out to be the most aligned. In the variants using calibrated seeds of a large fraction, the height of the seedlings varied from 13 to 23 cm.
3. The diameter of the root neck in crops with uncalibrated seeds varied from 1.86 mm to 11.94 mm, calibrated large seeds – from 3.88 to 4.56 mm, calibrated small seeds – from 2.99 to 3.41 mm.
4. The use of calibrated seeds allows you to obtain aligned planting material and significantly increase the yield of standard seedlings.

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