The practice of using a sieveless separator for pre-sowing treatment of common pine seeds (*Pinus sylvestris*)

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Abstract. The paper presents the results of studies on the effect of calibrating Scots pine (*Pinus sylvestris*) seeds on the morpho-biological characteristics of seedlings. The studies were carried out in 2017-2019. Scots pine seeds were used as the object of research. In the course of the research, laboratory and field methods were used. The seeds were calibrated using a sieveless separator, which makes it possible to obtain several tens of seed fractions with a size gap of 0.02 mm. It was found that plants of large seeds were characterized by a higher starting growth. Throughout the growing season, the advantage of these fractions persisted. Due to the higher growth rate of small fraction plants, the difference between plants decreased by the end of the growing season. By the end of the first year of vegetation, there was some advantage of large seedlings, the height of which varied from 6.95 cm (second fraction) to 7.18 cm (fourth fraction). The seedlings of these fractions were characterized by the highest uniformity (17.0%). At the end of the second growing season, the most intensive growth was noted in seedlings of large seeds, due to which a large planting material is formed, characterized by high uniformity.

1. Introduction

One of the main tasks of the forestry industry is the restoration of forestry areas. This is impossible without obtaining high quality seed material. It is known that the forest seed lot consists of seeds of different quality [1-4]. It was found that there is a positive relationship between the size and weight of seeds with the weight of seedlings and the relative growth rate [5], which is important for the design of sorting machines. Currently, in our country and abroad, various sieve devices are used. However, theory and practice have shown that the use of sieves does not give the desired result. The resulting fractions are characterized by low uniformity, the sieves are clogged with separation products and significant injury to the seeds [6]. Therefore, the creation of a fundamentally new device for calibrating seeds is urgent. We have created an experimental sample of a sieveless separator, which makes it possible to increase the yield of standard seedlings per unit area of a forest nursery by selecting for sowing seeds of fine fractions, which are not released when using sieve devices.

The purpose of the research was to test a fundamentally new sieve-free mechanism for pre-sowing preparation of Scots pine seeds. The scientific novelty of the research lies in the use of a device for calibrating forest seeds, in which an original working body is used to separate the seed blend.
2. Materials and methods
The studies were carried out in 2017-2019 on the territory of the Donskoy forestry enterprise of the Lipetsk region. Lipetsk Region is located in the Central Black Earth Region of the Russian Federation. In the course of the research, laboratory and field methods were used.

The object of research was common pine seeds with the following characteristics: the thickness of the seeds changed from 1.0 to 1.9 mm, the weight of 1000 pieces was 7.6 g, the weight of the entire batch was 24 kg, the purity of the seeds was 95%, the year of harvest of cones – 2016.

The seeds were calibrated using a sieve-free separator [7, 8]. The weight of 1000 seeds was determined as follows [9]. After thorough mixing of the seeds, two samples of 500 pcs were taken. Then the mass of each sample was measured and the average value was determined. The allowable discrepancy in the samples was established, after which the actual discrepancy between the samples was determined. By the smallest discrepancy between the samples, the weight of 1000 seeds was calculated as the sum of the weights of the two samples. The size gap was determined experimentally. The seeds were stratified before sowing. Sowing was carried out in the second decade of April with narrow-line sowing. After the emergence of seedlings, accounting plots with a length of 1 m were fixed with the fixation of control samples of seedlings. Uncalibrated seeds were used as a control. After emergence, seedlings were measured monthly. Statistical processing was performed using the *Statistica* 6.1 package.

Before sowing, the seeds were calibrated on a sieveless separator. 40 fractions of seeds with a size interval of 0.02 mm were obtained. The obtained fractions differed by the weight of 1000 pieces of seeds (table 1).

| Fraction | Gap size, mm | Weight of 1000 pcs, G | Fraction | Gap size, mm | Weight of 1000 pcs, G |
|----------|--------------|----------------------|----------|--------------|----------------------|
| 1        | 1.08-1.10    | 4.71                 | 21       | 1.48-1.50    | 6.83                 |
| 2        | 1.10-1.12    | 4.83                 | 22       | 1.50-1.52    | 6.86                 |
| 3        | 1.12-1.14    | 4.90                 | 23       | 1.52-1.54    | 6.97                 |
| 4        | 1.14-1.16    | 4.96                 | 24       | 1.54-1.56    | 7.17                 |
| 5        | 1.16-1.18    | 5.0                  | 25       | 1.56-1.58    | 7.41                 |
| 6        | 1.18-1.20    | 5.02                 | 26       | 1.58-1.60    | 7.43                 |
| 7        | 1.20-1.22    | 5.23                 | 27       | 1.60-1.62    | 7.61                 |
| 8        | 1.22-1.24    | 5.34                 | 28       | 1.62-1.64    | 7.82                 |
| 9        | 1.24-1.26    | 5.47                 | 29       | 1.64-1.66    | 8.00                 |
| 10       | 1.26-1.28    | 5.50                 | 30       | 1.66-1.68    | 8.01                 |
| 11       | 1.28-1.30    | 5.84                 | 31       | 1.68-1.70    | 8.16                 |
| 12       | 1.30-1.32    | 5.86                 | 32       | 1.70-1.72    | 8.27                 |
| 13       | 1.32-1.34    | 5.90                 | 33       | 1.72-1.74    | 8.75                 |
| 14       | 1.34-1.36    | 6.02                 | 34       | 1.74-1.76    | 8.80                 |
| 15       | 1.36-1.38    | 6.03                 | 35       | 1.76-1.78    | 8.82                 |
| 16       | 1.38-1.40    | 6.04                 | 36       | 1.78-1.80    | 8.96                 |
| 17       | 1.40-1.42    | 6.18                 | 37       | 1.80-1.82    | 9.16                 |
| 18       | 1.42-1.44    | 6.57                 | 38       | 1.82-1.84    | 9.33                 |
| 19       | 1.44-1.46    | 6.68                 | 39       | 1.84-1.86    | 9.34                 |
| 20       | 1.46-1.48    | 6.73                 | 40       | 1.86-1.88    | 9.57                 |

The difference between variants by weight 1000 pcs. seeds were no more than 2.5%. At the same time, between the individual fractions, a significant increase in the seed size was noted. Based on this, all factions were grouped into four groups:
1) from the 1st to the 10th fraction;
2) from the 11th to the 17th fraction;
3) from the 18th to the 32nd fraction;
4) from the 33rd to the 40th fraction. The first row included fractions with a small (4.5 - 5.5 g) weight of 1000 seeds, which accounted for 12% of the weight of the entire batch. The fraction of the second group (the weight of 1000 seeds 5.84 - 6.18 g) accounts for 22%. The bulk (about 55%) consisted of fractions of the third group, which had a mass of 1000 seeds from 6.5 to 8 g. Fractions of seeds included in the fourth group, weighing 1000 pieces above 8.5 g, accounted for about 10% of the mass of the entire batch.

3. Results and discussion
One of the most important indicators of the quality of Scots pine seedlings is plant height. In the course of the research, it was found that plants of large seeds, that is, the third and fourth groups, were characterized by a higher starting growth (table 2).

Table 2. The height of seedlings of Scots pine, 2017.

| Month     | Control | Group of fractions |
|-----------|---------|--------------------|
|           | 1       | 2                  | 3       | 4       |
| May       | 2.23    | 2.42               | 2.39    | 2.87    | 2.86    |
| June      | 3.00    | 3.14               | 3.05    | 3.19    | 3.38    |
| July      | 3.70    | 3.43               | 3.76    | 4.18    | 3.87    |
| August    | 4.30    | 4.30               | 4.27    | 4.92    | 5.09    |
| September | 5.41    | 5.73               | 5.74    | 5.85    | 5.51    |
| October   | 6.30    | 6.58               | 6.95    | 7.04    | 7.18    |

Throughout the growing season, the advantage of these fractions persisted. However, in the future, the growth rate of small plants was higher (figure 1), as a result of which the difference between plants of the first and fourth groups decreased to 0.6 cm.

Figure 1. The height of seedlings of Scots pine, 2017: H – growth of pine seedlings (cm), k – control variant of seedlings, 1, 2, 3, 4 – groups of seedlings.

Throughout the growing season, the difference between seedlings of different groups was insignificant. By the end of the growing season, there was a slight advantage of seedlings of large seeds, the height of which varied from 6.95 cm (second group) to 7.18 cm (fourth group). The height of the seedlings of the control variant was 6.3 cm (table 2).
One of the important requirements for seedlings is their uniformity. At the beginning of the growing season, the seedlings of the control variant were characterized by significant variability (33.0 %). Seedlings of the fourth group were characterized by the highest uniformity - 17.0 % (table 3).

**Table 3.** The coefficient of variation in plant height of seedlings of Scots pine, 2017.

| Month  | Group of fractions | Control | 1 | 2 | 3 | 4 |
|--------|--------------------|---------|---|---|---|---|
| May    | 33.01              | 19.98   | 20.32 | 19.19 | 17.02 |
| June   | 18.87              | 17.59   | 17.51 | 15.41 | 14.59 |
| July   | 16.81              | 16.59   | 17.74 | 16.32 | 11.50 |
| August | 19.27              | 16.93   | 23.15 | 16.73 | 20.12 |
| September | 23.09           | 16.92   | 22.01 | 16.00 | 22.73 |
| October | 17.65              | 18.46   | 17.27 | 17.84 | 16.43 |

Throughout the growing season, the variability of plant height in seedlings changed. The most stable indicators were characterized by the first and third fractions, which had a coefficient of variation of less than 20% throughout the growing season.

At the beginning of the second growing season, seedlings of all fractions developed slowly. During the first three months, their height changed by an average of 5 cm and the difference between the variants was insignificant (table 4). However, the seedlings of the control variant were still characterized by the greatest variability. The value of its coefficient of variation varied from 22.93 in August to 18.8 % in July. Seedlings of the third faction were characterized by the highest alignment. During the entire vegetation period of 2018, the coefficient value was at the level of 15 ... 17%, which corresponds to the low variability of the trait.

**Table 4.** Seedlings height of Scots pine, 2018.

| Month  | Group of fractions | Control | 1 | 2 | 3 | 4 |
|--------|--------------------|---------|---|---|---|---|
| May    | 7.99               | 7.45    | 7.56 | 7.75 | 7.84 |
| June   | 8.29               | 7.99    | 8.25 | 8.50 | 8.73 |
| July   | 12.66              | 12.84   | 13.63 | 13.06 | 14,16 |
| August | 14.30              | 17.79   | 16.60 | 16.52 | 17.82 |
| September | 16.23            | 18.31   | 19,05 | 18.81 | 19.92 |
| October | 17.02              | 20.92   | 21.59 | 25.23 | 26.55 |

Throughout the growing season, the variability in plant height in seedlings changed. The most stable indicators were characterized by the first and third groups, in which the coefficient of variation was less than 20% throughout the entire growing season (table 2, 3).

At the beginning of the second growing season, seedlings of all groups developed slowly. During the first three months, their height changed by an average of 5 cm and the difference between the options was insignificant (≤ 5%) (table 4).

A significant increase in altitude was noted in July. However, later this process slowed down, especially in plants of the control variant (figure 2).
At the end of the growing season (September-October), only seedlings of seeds of large fractions (third and fourth) were actively growing. As a result, their heights were 25.23 and 26.55 cm, respectively. Seedlings of other groups, including small seeds, were more than 20 cm high. Plants of the control variant were significantly inferior to all groups. Their height was only 17 cm (table 4, 5).

The plant height variability of seedlings varied during the second growing season. Plants of large fractions (third and fourth), in which the coefficient of variation was less than 20%, were more even. (table 5)

The seedlings of the control variant were characterized by the greatest variability. The value of their coefficient of variation varied from 22.93 in August to 18.8% in July. Seedlings of the third group were characterized by the highest uniformity. Throughout the entire growing season in 2018, the value of the coefficient was at the level of 15 - 17%, which corresponds to the low variability of the trait. It should be noted that by the end of the growing season the coefficient of variation for all seed fractions was less than 19%, which corresponds to the average level of variability (table 4, 5).

Table 5. The coefficient of variation in plant height of seedlings of Scots pine, 2018.

| Month     | Group of fractions |
|-----------|--------------------|
|           | Control | 1    | 2    | 3    | 4    |
| May       | 22.38   | 20.15 | 20.29 | 15.12 | 15.56 |
| June      | 20.37   | 22.72 | 17.44 | 14.49 | 19.39 |
| July      | 18.80   | 14.02 | 17.46 | 16.74 | 16.43 |
| August    | 22.93   | 17.68 | 22.45 | 22.71 | 19.12 |
| September | 19.57   | 16.08 | 17.37 | 16.57 | 13.44 |
| October   | 23.14   | 17.07 | 18.56 | 15.56 | 16.85 |

4. Conclusion
The studies carried out on the use of a fundamentally new sieveless mechanism for pre-sowing preparation of Scots pine seeds made it possible to establish the following.

The proposed method of sorting seeds with the use of a sieveless separator allows you to get equalized in size (thickness) and weight of 1000 pieces. fractions of seeds. When the obtained seed fractions are sown separately, the grown planting material is characterized by high uniformity.
Scots pine seedlings of different fractions differed in growth rates and uniformity of planting material. A high starting growth was noted in seedlings of large seeds. Seedlings from large seeds are characterized by better growth properties, especially under unfavorable conditions and more uniform planting material. Due to this, a large planting material is formed, characterized by high uniformity.

The use for sowing of fractions of small seeds isolated from the seed mixture using a sieveless separator allows increasing the yield of standard planting material.

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