The results of the use of gridless technology for the selection and sowing in a forest nursery of 1000 pieces equalized by weight and size (thickness) of Scotch pine seed fractions

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Abstract. The aim of our research is to analyze the quantitative composition of standard and non-standard Scots pine seedlings grown with all sowing options: calibrated small and large seeds, as well as uncalibrated seeds. As the material for the study, we used a batch of Scots pine seeds, which were divided by weight into two equal parts. Subsequently, one part was calibrated on a sieve-free separator in thickness into small and large fractions, and the second was not calibrated. The size gap in the calibrated fractions was determined experimentally based on the minimum and maximum size of the seed thickness. All the seeds obtained were sown separately from each other in the nursery areas. At the end of the second growing season, using the field method of accounting for the grown planting material, a sample of standard and non-standard seedlings was carried out. As a result, it was found that in crops with calibrated seeds of non-standard seedlings is 25 ... 30% less than in crops with non-calibrated seeds. Thus, sowing with Scots pine seeds calibrated in thickness makes it possible to significantly increase the productivity of forest nursery areas in comparison with sowing with uncalibrated seeds.

1. Introduction

Separation of Scots pine seeds by size must be carried out in order to rationally use both large and small seeds and create optimal conditions for the growth and development of seedlings. This is achieved by calibrating the seed for size (thickness). Seed sizing is one method of achieving uniform planting, getting more seedlings per unit of seed weight, and reducing competition between seedlings [1].

It should be noted that calibrating the thickness of Scots pine seeds is the most reliable criterion in the system for separating coniferous forest seeds by different physical properties. This conclusion is almost completely confirmed by foreign studies on coniferous seeds [2-5]. Leveling the seeds of Scots pine using the sieve-free technology on fractions by thickness and sowing these fractions separately from each other gives a positive effect. This effect is achieved by creating the best conditions for the growth and development of all seedlings: those that grow from small seeds, and those that grow from large seeds. This technique makes it possible to effectively use small seeds for sowing, which cannot be completely separated from the forest seed mixture with conventional sorting technology on sieve...
When growing seedlings from small seeds, there is no pressure on them from seedlings grown from large seeds, and they reach a standard size in their development. At the same time, when seedlings are grown separately from large seeds, due to the fact that there are practically no seedlings growing from small seeds, nutrients are more efficiently spent on the growth and development of these seedlings and they do not have significant height deviations among themselves, which positively affects their further growth and development on forest-cultivated areas [7-10].

In this regard, the aim of the research was to compare the quantitative composition of standard and non-standard Scots pine seedlings in all variants of sowing: with separate sowing of small, large and uncalibrated seeds in forest nursery areas.

2. Materials and methods
In 2019-2020, field studies were conducted on the territory of the "Don Forestry" of the Lipetsk region (geographical coordinates of the nursery: latitude N 52° 38.123 longitude E 38° 59.101) to account for standard and non-standard Scots pine seedlings. The object of research was Scots pine seeds, the characteristics of which are presented in table 1.

| The thickness of the seed, mm | Seed weight, g | Purity, % | Germination rate, % | Year of collection |
|-------------------------------|----------------|-----------|---------------------|--------------------|
| min 1.1                       | max 2.1        | 8.1       | 36000               | 96                 |

The seed batch of Scots pine was divided by weight into two equal parts before sowing. The first part was calibrated on a crate-free separator in thickness for small and large fractions [11-12]. The size gap in the fractions was determined experimentally. The second part of the seeds was not calibrated. In the future, the obtained seeds were sown separately from each other in forest-nursery areas.

Sowing was carried out in the second decade of April using a narrow-line method. At the end of the second growing season, four experimental plots were identified in all crops with a length of one meter each.

The resulting calibrated seed fractions and unsorted ones were sown separately in forest nursery areas.

3. Results and discussion
By the end of the second growing season, the quantitative composition of the grown seedlings was taken into account. The accounting results are presented in table 2. It can be seen that the number of non-standard seedlings on average is about 30 % of the total number of seedlings recorded in experimental plots. This indicates that a non-standard seedling is a seedling that has grown from small seeds, sown together with large seeds. In the future, non-standard seedlings should be rejected, which will lead to a significant decrease in the total number of seedlings suitable for planting in forest-cultivated areas.

![figures 1a-3d show photographs of real plots of selection and measurement of Scots pine seedlings. The figures show the difference in growth and development from calibrated large and small seeds. The difference in the growth and development of uncalibrated Scots pine seeds is visible. These figures show the reality of our research. Analyzing the data, we can conclude that the number of non-standard seedlings grown from small seeds of Scots pine calibrated by thickness is extremely insignificant and on average amounts to about 1 % of the total number of seedlings recorded in experimental plots (table 2). From this, it is logical to conclude that the calibration of Scots pine seeds by thickness makes it possible to obtain standard seedlings when dividing the crop with almost no losses associated with the rejection of non-standard seedlings.](image-url)
Table 2. Seedlings grown from Scots pine seeds.

| Experiment number | Total number of seedlings in experimental plots | Number of non-standard seedlings in the experimental plot | Number of non-standard seedlings in rows |
|-------------------|-----------------------------------------------|--------------------------------------------------------|---------------------------------------|
|                   |                                               | 1   | 2   | 3   |                                            |
| Uncalibrated small seeds |
| 1                 | 228                                           | 69  | 22  | 18  | 29                                         |
| 2                 | 213                                           | 73  | 25  | 28  | 20                                         |
| 3                 | 297                                           | 78  | 27  | 27  | 24                                         |
| 4                 | 249                                           | 89  | 24  | 23  | 35                                         |
| Uncalibrated large seeds |
| 1                 | 228                                           | 69  | 22  | 18  | 29                                         |
| 2                 | 213                                           | 73  | 25  | 28  | 20                                         |
| 3                 | 297                                           | 78  | 27  | 27  | 24                                         |
| 4                 | 249                                           | 89  | 24  | 23  | 35                                         |
| Calibrated small seeds |
| 1                 | 174                                           | 5   | 2   | 1   | 2                                          |
| 2                 | 197                                           | 8   | 3   | 1   | 4                                          |
| 3                 | 193                                           | 3   | 1   | 0   | 2                                          |
| 4                 | 159                                           | 4   | 2   | 2   | 0                                          |
| Calibrated large seeds |
| 1                 | 256                                           | 13  | 7   | 2   | 4                                          |
| 2                 | 291                                           | 8   | 3   | 2   | 3                                          |
| 3                 | 241                                           | 4   | 1   | 3   | 0                                          |
| 4                 | 277                                           | 5   | 2   | 1   | 2                                          |

The total number of seedlings growing in experimental plots is approximately equal to the total number of seedlings growing in experimental plots from uncalibrated seeds (table 2). A small number of non-standard seedlings (about 1% of the total number of seedlings) in experimental plots (table 2), in our opinion, is due to the presence of individual underdeveloped large seeds in the large fraction. It is not difficult to notice that when individual non-standard seedlings are culled from the grown planting material, the number of standard seedlings in these crops is significantly (by about 25%) higher than the number of standard seedlings grown from uncalibrated seeds.

In the course of research work to determine various approaches to the pre-sowing treatment of Scots pine seeds, it was found that the most effective for their separation into fractions by size (thickness) use of gridless technology. The efficiency of the sieveless technology is determined by its ability to calibrate Scots pine seeds with an accuracy of up to 0.02 mm, which is an order of magnitude higher than that of traditionally used sieve devices of various configurations. In this case, the completeness of the separation of the passing fraction is 98...99%. In addition, in the process of separation, injury to the seeds is completely excluded. Analyzing the operation of all machines and devices for sorting coniferous seeds by size, Prof. L. Sviridov noted their common drawback, which is that the holes of the sieves are clogged in shifts [6, 7]. Exploratory experimental studies have shown that when the cylindrical sieve is in operation for 10-15 minutes clogged with seeds 20-25%, 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 separating seeds is disrupted, and one fraction of seeds is mixed with another.
Figure 1. Seedlings grown from uncalibrated Scots pine seeds on experimental plot #1 (a), #2 (b), #3 (c), and #4 (d).

Figure 2. Seedlings grown from calibrated small Scots pine seeds on experimental plot #1 (a), #2 (b), #3 (c), and #4 (d).
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(a) (b)

(c) (d)

Figure 3. Seedlings grown from calibrated large Scots pine seeds on experimental plot #1 (a), #2 (b), #3 (c), and #4 (d).

4. Conclusion

Obtaining standard seedlings from seeds of coniferous species (Scots pine) in conditions of growth and development in forest nurseries is one of the main tasks of forestry. The largest number of non-standard seedlings at the end of the second vegetative period was recorded on experimental plots in crops with uncalibrated seeds. In the crops with large seeds calibrated in thickness at the end of the second vegetative period, approximately the same number of seedlings is noted as compared to crops with uncalibrated seeds, however, the number of non-standard seedlings in them is tens of times less than in crops with uncalibrated seeds.

The total number of seedlings grown from calibrated small seeds on experimental plots is about 30% less than in other crops, while the number of non-standard seedlings in them is ten times less than in crops with uncalibrated seeds. Thus, despite the fact that the total number of Sents in crops with uncalibrated Scots pine seeds is much higher than in crops with calibrated small seeds, the number of standard seedlings in the latter is greater.

Separation of Scots pine seeds by size must be carried out for the rational use of both large and small seeds, while creating optimal conditions for the growth and development of seedlings. This technique makes it possible to effectively use small seeds for sowing, which cannot be completely isolated from the forest seed mixture with the usual sieve calibration technology. In addition, by reducing the number of non-standard seedlings in sowing with large seeds, due to the absence of rejection of non-standard seedlings, a double effect can be obtained. Firstly, the grown seedlings in sowing with large seeds almost completely correspond to the standard and their number is about 25% more than in sowing with uncalibrated seeds. Secondly, by sowing small seeds separately, we additionally get a significant number of standard seedlings, which, if sown with uncalibrated seeds, would be rejected as non-standard.

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