Selection of Scots pine seedling growth stimulants in extreme conditions of the Northern Kazakhstan steppe zone

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Abstract. The aim of this research is to determine optimal methods of using stimulants in a pre-sowing treatment of common pine seeds to increase their germination and obtain high-quality planting material. A study has been performed in forest nurseries of the State Forest Natural Reserve (SFNR) “Ertis Ormany” (Pavlodar region) and the Arykbalyk Branch of the State National Natural Park (SNNP) “Kokshetau” (Akmola region). The research is done with one- and two-year-old seedlings of ordinary pine sowing of 2017. A presowing seed preparation is carried out according to six options by using various types of stimulants. A method of mathematical processing of the thus obtained measurements of the seedlings with an insufficient number of measured plants is proposed by using a bootstrap analysis with and without quantile information. It allows one to estimate the influence of stimulants on the average growth of one- and two-year-old seedlings at a reliable level. As a result of these studies, it has been revealed that the pre-sowing treatment of pine seeds with ordinary stimulants increases the average height of annual seedlings. However, the results obtained in this experiment depend on the region of nursery location, but the use of soil irrigation with an “EridGrow” activator has increased the average height in both nurseries: by 13.9% in the “Kokshetau” SNNP for one-year-old seedlings, by 37.2% for two-year-old seedlings compared with the average height of the control seedlings. For pine seedlings in the “Ertis Ormany” SFNR nursery the influence of the stimulants is insignificant, but the positive effect on the average growth with the “EridGrow” soil irrigation is a 7.3% increase in the first year and a 24.7% one in the second year.

Key words: seedling, stimulant, pre-sowing treatment, average tree height, bootstrap analysis

1. Introduction

The effectiveness of forestry operations largely depends on the quality of planting material, which can only be grown in optimal environmental conditions [1]. If agricultural technology does not ensure the modeling of optimal conditions and acquisition of well–developed seedlings throughout the entire period of planting material growth, such planting material will take longer and harder to grow in forest crops in the first years. Since in Kazakhstan the cultivation of seedlings in forest nurseries is carried out according to extensive technology, the planting material is rarely standard and its output per unit area does not meet the GOST. Furthermore, the existing recommendations are outdated with the emergence of new means of mechanization, various bio–based additives and methods of growing seedlings. There are numerous works in the scientific literature dedicated to innovative methods of growing planting material, including the use of various stimulants, but they are scattered in nature, and the research results vary depending on the type of stimulants used, research regions, and tree species. Therefore, there is a need for careful development of regional recommendations. Plant growth stimulants are actively used in agriculture, and there are many methods for plant growth escalation [2–4]. In the near–abroad and far–abroad countries, new methods are being developed for pre–sowing treatment of woody plant seeds using stimulants [7–9], fungicides [10], unconventional preparations [11], various radiation treatments, and others [12]. The researchers have found that soaking seeds in
stimulants increases the soil germination of seeds and positively affects the growth and condition of seedlings [13]. In forestry, to obtain planting material that is resistant to climatic and landscape conditions, a variety of growth substances are used for presowing seed treatment [14–21].

The relevance of research is beyond doubt in need of a scientifically–based system for growing standard planting stock of the main forest–forming species by using innovative ways that include the use of stimulants for pre–sowing seed treatment due to the current climate change, environmental degradation, and the emergence of various new types of biostimulants.

2. Research methods
The aim of the research is to determine the assortment of optimal stimulants, their concentration and exposure time for pre–sowing treatment of common pine seeds to increase their germination and obtain high–quality planting material. The studies were performed in the forest nurseries of the State Forest Natural Reserve (SFNR) “Ertis Ormany” (Pavlodar region) and the Arykbalyk Branch of the State National Natural Park (SNNP) “Kokshetau” (Akmola region).

The SFNR “Ertis Ormany” is located in a dry steppe subzone. The climate is sharply continental, with cold, relatively little snowfall winters and hot, dry summers. It is characterized by large daily and annual amplitudes of the air temperature. The lowest temperature is −520C in winter and +460C in summer. The average monthly temperature in July ranges from 20 to 220C, and the average annual temperature ranges from 3 to 2.80C. There is little rainfall: 130–200 mm per year, and during the summer period droughts are a frequent occurrence. The duration of the growing season is 176 days on average. There is a formation of sandy soil in the pine forest of the nursery.

The Arykbalyk Branch of the “Kokshetau” SNNP is located in a forest–steppe zone with a sharply continental climate, which is characterized by dry, hot summers with average temperatures in July of 18–190C, low air temperatures in winter (up to −450C) with a small amount of summer and winter precipitation. In addition, climatic factors unfavorable for the growth of woody vegetation are characterized by late spring and early autumn frosts, droughts, and strong winds. The type of soils in the nursery is alfisol.

Observations were carried out for ordinary pine seedlings of the first year of life in 2016 and when they reached two years of age in 2017. The pre–sowing preparation of seeds was carried out according to the following options:
– soaking the seeds of common pine for 5 minutes using the biostimulator “Extrasol” in two concentrations: 0.1–0.05%;
– spraying seeds with “Extrasol” with a similar concentration;
– soaking seeds in the bio–stimulator “Humate + 7 trace elements” for 18 and 24 hours;
– soaking seeds in the “HDD” stimulator for 5 minutes;
– spraying seeds with the “HDD” stimulator;
– irrigation of the soil with the “EridGrow” soil activator.

One liter of “EridGrow” soil activator was dissolved in 10 liters of water and 1 m2 of soil was watered with this solution. The seeds were soaked in “Extrasol”, previously the stimulant was dissolved in water at a concentration of 0.1% – 10 ml / 1 l, at a concentration of 0.05% – 5 ml / 1 l. “Humate + 7 trace elements” was used at a concentration of 0.5 g per 1 liter of water. One gram of the “HDD” stimulator was dissolved in 1 liter of water and used to soak the seeds. The “HDD” stimulator was invented by Kazakhstan scientists that passed production tests. It is a fine–grained black powder of organic origin, which is based on humic preparations. Other stimulants are recommended for use in agriculture, but have not been tested in forestry.

Spring seeding was carried out manually according to the 6–line pattern in the SFNR “Ertis Ormany” and according to the 5–line pattern in the Arykbalyk Branch of the SNNP “Kokshetau”. The width of the seed tape was 1.2 m, the length of the stitch in one experiment was 2 linear meters, and the distance between the stitches was 20 cm. Each experiment was performed in duplicate. About 250 seeds were sown per 1 meter, which corresponds to the seeding rate. Observations of the growth of seedlings were carried out according to the Smirnov N.A. method [10]. For measurements, the
accounting segment was selected on each line in two replicates, on which at least 100 seedlings were measured. The plant height was measured from the soil surface to the apical bud with an accuracy of 0.1 cm. The control was seeds and seedlings of Scots pine grown without the use of stimulants.

3. The results and discussion

Tables 1–4 and Figures 1–2 show the initial indicators of the considered samples for the nurseries of the SNNP “Kokshetau” and SFNR “Ertis Ormany” for 2016 and 2017.

Note that in the nursery of the SNNP “Kokshetau” all stimulants led to an increase in the tree growth compared to the control group of seeds which was not exposed to any treatment, while the improvement in the average growth was more significant after the second year of plant life (Tables 1, 2). The best results for both years were obtained by the use of the “Humate + 7 trace elements” stimulator and the “EridGrow” irrigation. A year after treatment “EridGrow” irrigation showed an increase in height by 14.1%, after two years by 37.2%, while the stimulator “Humate + 7 trace elements” showed an increase by 20.2% and 30.4% compared to the tree height of the control group. For the nursery in the SFNR “Ertis Ormany”, the influence of stimulants was not so apparent (Tables 3, 4). A stable, albeit insignificant positive effect for two years was achieved by irrigation with the “EridGrow” stimulator with an increase by 7% in the first year and 24.7% in the second year.

It can be seen from the figures that in the different nurseries the height of the plants is significantly different; however, the effect of stimulants on the average growth shows some similarities. Note that the sizes of the samples vary widely depending on the year of life of the seedlings and the nursery location. Moreover, the measurement results were rounded or not accurate enough (the accuracy was 5 mm), which ultimately led to the lack of data normality and, consequently, to the inability to use standardized statistical procedures to show the presence of differences in the samples. As a result, to identify the influence of stimulants on the average plant growth, the bootstrap sample propagation method was used [22], which allows one to find true values of the average plant growth as if all the trees in the study were measured, and not just those that were in the sample size. The bootstrap simulation parameter is $M=10^5$.

The bootstrap method has shown that, regardless of the stimulator, the average growth of one- and two-year-old pines is normally distributed (see Figs. 3 and 4), but the distribution parameters (the mean and standard deviation (SD)) are different. From Tables 5–8 one can see that the most effective treatment involves irrigation of the soil with the “Extrasol” stimulant with different concentrations (Ex 0.05 and 0.1 spray) and the “EridGrow” activator (ErGrw irrigation), spraying with HDD spray, presowing treatment of seeds with the stimulants HDD (HDD 5 min), “Humate + 7 trace elements” (Hum + 7 18 h and Hum + 7 24 h), and “Extrasol” (Ex 0.1 5 min).
### Table 1. Statistical indicators of pine height in cm for the nursery SNNP “Kokshetau”, the first year of plant life.

| Indicators | Stimulator                  | Extrasol 0.05 5min | Extrasol 0.1 spray | Extrasol 0.1 5min | Extrasol 0.05 spray | HDD spray | HDD 5min | Erich Grow irrigation | Hu mate 18 hr | Hu mate 24 hr | Control |
|------------|-----------------------------|---------------------|--------------------|-------------------|---------------------|-----------|----------|----------------------|--------------|--------------|---------|
| Mean       |                             | 2.786               | 2.627              | 2.635             | 2.670               | 2.824     | 2.731    | 2.825                | 2.977        | 2.573        | 2.481   |
| Median     |                             | 2.700               | 2.500              | 2.500             | 2.600               | 2.800     | 2.600    | 2.800                | 2.800        | 2.500        | 2.200   |
| Mode       |                             | 2.500               | 2.500              | 2.500             | 2.500               | 2.500     | 2.500    | 2.500                | 2.500        | 2.500        | 2.200   |
| SD         |                             | 0.775               | 0.786              | 0.811             | 0.867               | 0.840     | 0.769    | 0.913                | 0.948        | 0.795        | 0.978   |
| Kurtosis   |                             | -0.567              | 2.061              | -0.068            | 0.114               | -0.059    | -0.098   | -0.248               | 0.565        | 0.691        | -0.019  |
| Skewness   |                             | 0.173               | 0.762              | 0.474             | 0.567               | 0.425     | 0.367    | 0.365                | 0.786        | 0.706        | 0.772   |
| Minimum    |                             | 1.200               | 1.000              | 1.000             | 0.800               | 1.000     | 1.200    | 1.000                | 1.400        | 1.000        | 0.900   |
| Maximum    |                             | 4.500               | 6.500              | 5.000             | 5.500               | 5.400     | 5.100    | 5.500                | 6.300        | 5.500        | 5.600   |
| Sample size|                             | 202                 | 200                | 200               | 202                 | 204       | 203      | 203                  | 203          | 201          | 200     |

### Table 2. Statistical indicators of pine height in cm for the nursery SNNP “Kokshetau”, the second year of plant life.

| Indicators | Stimulator                  | Extrasol 0.05 5min | Extrasol 0.1 spray | Extrasol 0.1 5min | Extrasol 0.05 spray | HDD spray | HDD 5min | Erich Grow irrigation | Hu mate 18 hr | Hu mate 24 hr | Control |
|------------|-----------------------------|---------------------|--------------------|-------------------|---------------------|-----------|----------|----------------------|--------------|--------------|---------|
| Mean       |                             | 7.738               | 7.063              | 6.350             | 6.963               | 7.263     | 7.338    | 8.575                | 8.150        | 7.563        | 6.250   |
| Median     |                             | 7.500               | 6.500              | 6.000             | 6.500               | 7.000     | 7.000    | 8.000                | 7.750        | 7.500        | 5.750   |
| Mode       |                             | 7.000               | 4.000              | 5.500             | 6.000               | 7.000     | 6.000    | 9.000                | 6.000        | 6.000        | 5.000   |
| SD         |                             | 2.970               | 2.615              | 1.840             | 1.809               | 1.536     | 1.956    | 1.966                | 2.179        | 2.410        | 2.589   |
| Kurtosis   |                             | 1.507               | 0.549              | -0.242            | 0.225               | -0.188    | -0.105   | 0.277                | -1.413       | -0.352       | -0.845  |
| Skewness   |                             | 0.792               | 0.827              | 0.566             | 0.665               | 0.257     | 0.360    | 0.583                | 0.199        | 0.458        | 0.367   |
| Minimum    |                             | 2.000               | 3.500              | 3.000             | 3.500               | 4.500     | 3.500    | 5.000                | 5.000        | 3.500        | 2.000   |
| Maximum    |                             | 17.000              | 15.000             | 11.000            | 11.500              | 11.000    | 12.000   | 14.000               | 11.500       | 13.000       | 11.500  |
| Sample size|                             | 40                  | 40                 | 40                | 40                  | 40        | 40       | 40                   | 40           | 40           | 40      |
Table 3. Statistical indicators of pine height in cm for the nursery SFNR “Ertis Ormany”, the first year of plant life.

| Indicators | Stimulator |
|------------|------------|
|            | Extrasol Extrasol Extrasol HDD HDD Erid | Hu mate | Hu mate | Control |
|            | 0.05 0.1 0.05 5min 0.1 spray 0.05 5min spray 5min | irrigation | 18 hr | 24 hr |         |
| Mean       | 4.481 4.044 5.044 4.287 4.677 4.152 4.939 4.228 4.144 4.600 |
| Median     | 4.500 4.000 4.500 4.000 4.500 4.000 4.000 4.000 4.000 4.000 |
| Mode       | 4.000 4.000 4.000 4.000 5.000 3.500 4.000 4.000 4.000 4.000 |
| SD         | 1.080 1.080 1.360 0.994 0.837 0.748 0.918 0.792 0.861 1.142 |
| Kurtosis   | –0.118 –0.026 –0.585 1.442 –0.543 –0.722 –0.934 –0.643 3.372 –0.300 |
| Skewness   | 0.366 0.449 0.509 0.817 0.164 0.026 0.110 0.183 1.293 0.516 |
| Minimum    | 2.500 2.000 2.500 2.500 3.000 2.500 3.000 3.000 2.500 2.500 |
| Maximum    | 7.500 6.500 8.500 8.000 6.500 5.500 6.500 6.000 7.500 7.500 |
| Sample size| 80 80 80 75 82 79 82 79 80 75 |

Table 4. Statistical indicators of pine height in cm for the nursery SFNR “Ertis Ormany”, the second year of plant life.

| Indicators | Stimulator |
|------------|------------|
|            | Extrasol Extrasol Extrasol HDD HDD Erid | Hu mate | Hu mate | Control |
|            | 0.05 0.1 0.05 5min 0.1 spray 0.05 5min spray 5min | irrigation | 18 hr | 24 hr |         |
| Mean       | 11.694 15.326 11.295 11.310 11.702 13.525 14.450 13.638 12.413 11.587 |
| Median     | 11.000 16.000 11.250 11.250 11.250 13.500 14.000 14.000 12.500 11.000 |
| Mode       | 11.000 13.000 10.000 7.500 6.000 13.500 12.000 14.000 8.000 11.000 |
| SD         | 4.076 3.197 3.109 4.412 4.064 3.402 3.099 2.658 3.924 3.172 |
| Kurtosis   | –1.128 0.801 –0.353 –0.541 –0.067 0.421 –0.461 –0.060 –1.087 –0.784 |
| Skewness   | –0.004 –0.385 0.139 0.443 0.496 0.429 0.756 –0.413 0.279 0.417 |
| Minimum    | 5.000 7.000 5.500 4.000 6.000 6.500 10.000 7.000 6.500 7.000 |
| Maximum    | 19.000 21.500 19.000 22.000 23.000 23.000 20.500 18.000 20.000 18.000 |
| Sample size| 31 23 40 42 42 40 20 40 40 40 |
Figure 1. Height of annual plants in two nurseries: R – SFNR “Ertis Ormany”, A – SNNP “Kokshetau”.

Figure 2. Height of biennial plants in two nurseries: R – SFNR “Ertis Ormany”, A – SNNP “Kokshetau”.

Table 5. Parameters of bootstrap distribution of pine height in cm for the nursery SFNR “Ertis Ormany”, the first year of plant life.

|                | Extrasol 0.1 spray | Extrasol 0.05 5 min | Extrasol 0.1 spray | Extrasol 0.05 5 min | Erdisol Grow irrigation | HDD spray | HDD 5 min | Humate 18hr | Humate 24hr | Control |
|----------------|--------------------|----------------------|--------------------|----------------------|-------------------------|-----------|-----------|-------------|-------------|---------|
| Mean           | 4.287              | 4.144                | 5.003              | 4.481                | 4.672                   | 4.162     | 4.969     | 4.218       | 4.244       | 4.610   |
| Median         | 4.286              | 4.043                | 5.043              | 4.481                | 4.676                   | 4.152     | 4.940     | 4.228       | 4.143       | 4.600   |
| Mode           | 4.250              | 4.000                | 5.000              | 4.500                | 4.680                   | 4.167     | 4.942     | 4.250       | 4.167       | 4.500   |
| SD             | 0.066              | 0.070                | 0.088              | 0.070                | 0.053                   | 0.049     | 0.059     | 0.052       | 0.056       | 0.077   |
Table 6. Parameters of bootstrap distribution of pine height in cm for the nursery SFNR “Ertis Ormany”, the first year of plant life.

|                | Ex trasol 0.05 spray | Ex trasol 0.1 spray | Ex trasol 0.1 spray | HDD spray 5min | HDD spray 5min | ErirGrow Irrigation | Hu mate 18hr | Hu mate 24hr | Control |
|----------------|----------------------|---------------------|---------------------|-----------------|-----------------|---------------------|--------------|--------------|---------|
| Mean           | 11.309               | 15.112              | 11.284              | 11.696          | 11.713          | 13.523              | 14.562       | 13.635       | 12.410   |
| Median         | 11.309               | 15.328              | 11.293              | 11.701          | 13.524          | 14.450              | 13.639       | 12.409       | 11.587   |
| Mode           | 11.320               | 15.500              | 11.200              | 11.705          | 13.500          | 14.500              | 13.500       | 12.500       | 11.500   |
| SD             | 0.280                | 0.272               | 0.302               | 0.260           | 0.222           | 0.282               | 0.172        | 0.255        | 0.207    |

Table 7. Parameters of bootstrap distribution of pine’s height in cm for the nursery SNNP “Kokshetau”, the first year of plant life.

|                | Ex trasol 0.05 spray | Ex trasol 0.1 spray | Ex trasol 0.1 spray | HDD spray 5min | HDD spray 5min | ErirGrow Irrigation | Hu mate 18hr | Hu mate 24hr | Control |
|----------------|----------------------|---------------------|---------------------|-----------------|-----------------|---------------------|--------------|--------------|---------|
| Mean           | 2.789                | 2.629               | 2.634               | 2.678           | 2.831           | 2.726               | 2.829        | 2.980        | 2.569    |
| Median         | 2.790                | 2.626               | 2.634               | 2.677           | 2.831           | 2.726               | 2.829        | 2.980        | 2.569    |
| Mode           | 2.795                | 2.635               | 2.627               | 2.669           | 2.838           | 2.723               | 2.830        | 2.986        | 2.564    |
| SD             | 0.050                | 0.051               | 0.052               | 0.056           | 0.054           | 0.050               | 0.059        | 0.062        | 0.063    |

Table 8. Parameters of bootstrap distribution of pine height in cm for the nursery SNNP “Kokshetau”, the second year of plant life.

|                | Ex trasol 0.05 spray | Ex trasol 0.1 spray | Ex trasol 0.1 spray | HDD spray 5min | HDD spray 5min | ErirGrow Irrigation | Hu mate 18hr | Hu mate 24hr | Control |
|----------------|----------------------|---------------------|---------------------|-----------------|-----------------|---------------------|--------------|--------------|---------|
| Mean           | 7.739                | 7.063               | 6.350               | 6.977           | 7.262           | 7.337               | 8.587        | 8.139        | 7.562    |
| Median         | 7.739                | 7.062               | 6.351               | 6.963           | 7.261           | 7.336               | 8.575        | 8.149        | 7.560    |
| Mode           | 7.745                | 7.062               | 6.322               | 6.956           | 7.295           | 7.330               | 8.604        | 8.162        | 7.554    |
| SD             | 0.189                | 0.166               | 0.117               | 0.116           | 0.098           | 0.124               | 0.126        | 0.138        | 0.154    |

Figure 3. Densities of the normal distribution of average height estimates obtained by the bootstrap method for pines of the second year of life, SNNP nursery “Kokshetau” (in cm).
Figure 4. Densities of the normal distribution of average height estimates obtained by the bootstrap method for pines of the second year of life, SFNR nursery “Ertis Ormany” (in cm).

It is interesting to note that according to the SFNR “Ertis Ormany” some stimulants have led to a decrease in the average height of plants compared to the control group both in the first and second years of plant life, which is explained by inaccuracy in the measurements (rounding) and small sample size, especially for the plant height of the second year of life, where the sample size of the control group \( N = 40 \). To correct this inaccuracy, additional expert information was used for the control group, according to which two-year-old pines in only 1% of cases have a height below 3 cm, i.e., in fact, we know the quantile \( q = 3 \) cm of the cumulative distribution function (cdf) \( F(x) = P(X \leq x) \) random variable (rv) \( X \) – the height of two-year-old pines and its level \( q = 0.01 \):

\[
F(x_q) = q. \tag{1}
\]

This allows us to find a more accurate estimate of the average height of biennial pines in the control group using the formula [23]:

\[
X_q = \frac{1}{N(N-1)} \sum_{i=1}^{N} \sum_{j=1, i \neq j}^{N} X_i \left\{ 1 - \frac{I(x_i \leq x_q) - q}{q(1-q)} \frac{I(x_j \leq x_q) - q}{q(1-q)} \right\}, \tag{2}
\]

where observations \( X_1, X_2, \ldots, X_N \) are independent, equally distributed rv with cdf \( F(x) \), \( I(x) \) – the indicator function. It is well-known that the estimate (2) is asymptotically unbiased, normally distributed with the variance [24]:

\[
\text{Var}\left\{X_q\right\} = \frac{\sigma^2}{N} - \frac{1}{N} E^2 \left\{ \frac{X \cdot I(X \leq x_q) - q}{q(1-q)} \right\} + O\left( \frac{1}{N^2} \right), \tag{3}
\]

where \( \sigma^2 = N \cdot \text{Var}\{X\} = \text{Var}\{X\} \) is the variance of the usual mean estimate \( \bar{X} = \frac{1}{N} \sum_{i=1}^{N} X_i \). From formula (3) it follows that

\[
\sigma_q^2 = \lim_{N \to \infty} N \cdot \text{Var}\left\{X_q\right\} = \sigma^2 - \left( \frac{1-q}{q} \cdot \int_{-\infty}^{x_q} x dF(x) - \int_{-\infty}^{\frac{q}{1-q}} x dF(x) \right)^2, \tag{4}
\]

that is for large enough \( N \) \( \sigma_q^2 \leq \sigma^2 \). Hence, due to the asymptotic objective the new estimate is more accurate than the classical one. Figure 5 shows a graph of dependence of \( \sigma_q^2 \) on \( q \) and \( \sigma^2 = \sqrt{12} \) for
$F(x) = U_{(0,1)}(x) \quad \text{– a uniform in (0,1) cdf [25]. Also note that the accuracy of the estimate } \bar{X}^q \text{ was investigated using simulation modeling. Figure 4 shows values of the standardized for } N \text{ mean squared error (MSE) } N \cdot \text{MSE}\{\bar{X}^q\} = N \cdot E\{\bar{X}^q - a\}^2 \text{ for } N > 5. F(x) = N_{(0,1)}(x) \text{ is the standard normal cdf, } x_q = 0, q = 0.5, \text{ obtained by simulation modeling with the number of iterations } R=10^5. \text{ Here } a = EX. \text{ Figure 6 shows that taking into account the additional information (1) has made it possible to significantly increase the accuracy of estimating the average, since for all considered values of } N > 5 \text{ the error } N \cdot \text{MSE}\{\bar{X}^q\} < N \cdot \text{MSE}\{\bar{X}\} \approx 1.$

![Figure 5](image)

**Figure 5.** Dependence of $\sigma^2_q$ on $q$ and $\sigma^2 = \frac{1}{12}$ for $F(x) = U_{(0,1)}(x)$.

![Figure 6](image)

**Figure 6.** Values of stimulated $N \cdot \text{MSE}\{\bar{X}^q\}$ and $N \cdot \text{MSE}\{\bar{X}\}$ depending on $N > 5$ for $F(x) = N_{(0,1)}(x)$, $x_q = 0$, $q = 0.5$, $R = 10^5$.

Using formula (2) to calculate a more accurate value of the average height of two–year–old plants of the control group of the nursery SFNR “Ertis Ormany”, we have found that $\bar{X}^q = 10.226 \text{ cm, while } \bar{X} = 11.587 \text{ cm, which is actually } 1.361 \text{ cm less. This implies that the use of additional information showed that all stimulants had a beneficial effect on the height of the plants. Figure 7 shows the graphs of distribution densities } p_q(x) \text{ for } \bar{X}^q \text{ and } p(x) \text{ for } \bar{X} \text{ obtained by using bootstrap modeling with a modeling parameter } M=10^5.$
4. Conclusions
As a result of the research performed above it has been revealed that the presowing treatment of pine seeds with ordinary stimulants positively affects the annual seedlings by increasing their average height. However, the results thus obtained depend on the region of the nursery location. In the SNNP “Kokshetau” the average height of the annual seedlings in the experiment with irrigation of the soil with an “EridGrow” activator increased by 13.9%, the two–year–old seedlings increased by 37.2% compared to the control seedlings. For pine seedlings in the SFNR “Ertis Ormany” nursery, the influence of stimulants turned out to be insignificant, but the positive effect on the growth with the “EridGrow” soil irrigation is 7% in the first year and 24.7% in the second year. Therefore, for the conditions of the SFNR “Ertis Ormany” nursery, in order to increase the height of the common pine seedlings it is recommended to irrigate the soil with the “EridGrow” activator with a dose of 1 liter per 10 liters of water for 1 m²; for the SNNP “Kokshetau” nursery, in addition to watering the soil with the “EridGrow” activator, soaking the seeds in “Humate + 7 trace elements” with a dose of 0.5 g per 1 liter of water for 18 hours is recommended. For the first time in forestry research, a method of mathematical processing of the thus obtained measurements of seedlings with an insufficient number of measured plants was proposed by using a bootstrap analysis with and without additional quantile information that allows one to estimate the effect of stimulants on the growth of one– and two–year–old seedlings at a reliable level.

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