



The selection of Scots pine seedlings' growth stimulants in extreme conditions of the Northern Kazakhstan steppe zone

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Applied research methods Description

- The aim:
 - to determine the 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 conducted in the two forest nurseries areas:
 - i. The State Forest Natural Reserve (SFNR) “Ertis Ormany” .
 - ii. The Arykbalyk branch of the State National Natural Park (SNNP) “Kokshetau” .

SFNR “Ertis Ormany” and the Arykbalyk branch of the “Kokshetau

- SFNR “Ertis Ormany” is located in the dry steppe subzone.
- The Arykbalyk branch of the “Kokshetau” SNNP is located in the forest–steppe zone with a sharply continental climate, which is characterized by dry and hot summers.

Pine seedlings

- ✓ 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 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.

Table 1. Statistical indicators of pine height in cm for the nursery SNNP “Kokshetau”, the first year of plant life, 2016

Indicator s	Stimulator									
	<u>Ex</u> <u>trasol</u> 0.05 5min	<u>Ex</u> <u>trasol</u> 0.1 spray	<u>Ex</u> <u>trasol</u> 0.1 5min	<u>Ex</u> <u>trasol</u> 0.05 spray	HDD spray	HDD 5 min	<u>Erid</u> <u>Grow</u> <u>irriga</u> <u>-tion</u>	Hu mate 18hr	Hu mate 24hr	<u>Cont</u> <u>rol</u>
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	2.800	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	–	–	–	–	–	–	–	–	–	–
Skewnes s	0.567	2.061	0.068	0.114	0.059	0.098	0.248	0.565	0.691	0.019
Minimu m	0.173	0.762	0.474	0.567	0.425	0.367	0.365	0.786	0.706	0.772
Maximu m	1.200	1.000	1.000	0.800	1.000	1.200	1.000	1.400	1.000	0.900
Sample size	4.500	6.500	5.000	5.500	5.400	5.100	5.500	6.300	5.500	5.600
	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.

Indicator s	Stimulator									
	Ex trasol 0.05 5min	Ex trasol 0.1 spray	Ex trasol 0.1 5min	Ex trasol 0.05 spray	HDD spray	HDD 5 min	Erid Grow irrigation	Hu mate 18hr	Hu mate 24hr	Cont-rol
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
Skewnes s	0.792	0.827	0.566	0.665	0.257	0.360	0.583	0.199	0.458	0.367
Minimu m	2.000	3.500	3.000	3.500	4.500	3.500	5.000	5.000	3.500	2.000
Maximu m	17.00	15.00	11.00	11.50	11.00	12.00	14.00	11.50	13.00	11.50
Sample size	0	0	0	0	0	0	0	0	0	0
	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

Indicator	Stimulator									
	<u>Ex</u> <u>trasol</u> 0.05 5min	<u>Ex</u> <u>trasol</u> 0.1 spray	<u>Ex</u> <u>trasol</u> 0.1 5min	<u>Ex</u> <u>trasol</u> 0.05 spray	HDD spray	HDD 5 min	<u>Erid</u> <u>Grow</u> <u>iriga</u> <u>-tion</u>	Hu mate 18hr	Hu mate 24hr	<u>Cont-</u> <u>rol</u>
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	5.000	4.000	4.000	4.500
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

Indicator s	Stimulator									
	<u>Ex trasol</u> 0.05 5min	<u>Ex trasol</u> 0.1 spray	<u>Ex trasol</u> 0.1 5min	<u>Ex trasol</u> 0.05 spray	HDD spray	HDD 5 min	<u>Erid Grow</u> <u>irriga</u> <u>-tion</u>	Hu mate 18hr	Hu mate 24hr	<u>Cont</u> <u>rol</u>
Mean	11.69	15.32	11.29	11.31	11.70	13.52	14.45	13.63	12.41	11.58
Median	11.00	16.00	11.25	11.25	11.25	13.50	14.00	14.00	12.50	11.00
Mode	11.00	13.00	10.00	7.500	6.000	0	0	0	8.000	0
SD	4.076	3.197	3.109	4.412	4.064	3.402	3.099	2.658	3.924	3.172
Kurtosis	—	—	—	—	—	—	—	—	—	—
Skewnes	1.128	0.801	0.353	0.541	0.067	0.421	0.461	0.060	1.087	0.784
Minimum	0.004	0.385	0.139	0.443	0.496	0.429	0.756	0.413	0.279	0.417
Maximum	5.000	7.000	5.500	4.000	6.000	6.500	10.00	7.000	6.500	7.000
Sample size	19.00	21.50	19.00	22.00	23.00	23.00	20.50	18.00	20.00	18.00
	0	0	0	0	0	0	0	0	0	0
	31	23	40	42	42	40	20	40	40	40

Chart Area



Figure 1. The height of annual plants in two nurseries: R – SFNR “Ertis Ormany”, A – SNNP “Kokshetau”

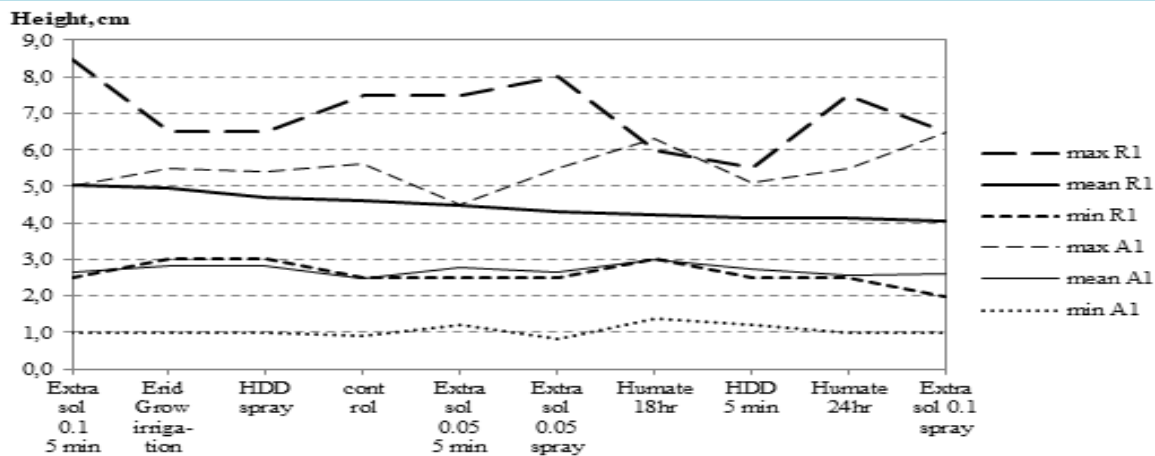


Figure 2. The height of biennial plants in two nurseries: R – SFNR “Ertis Ormany”, A – SNNP “Kokshetau”

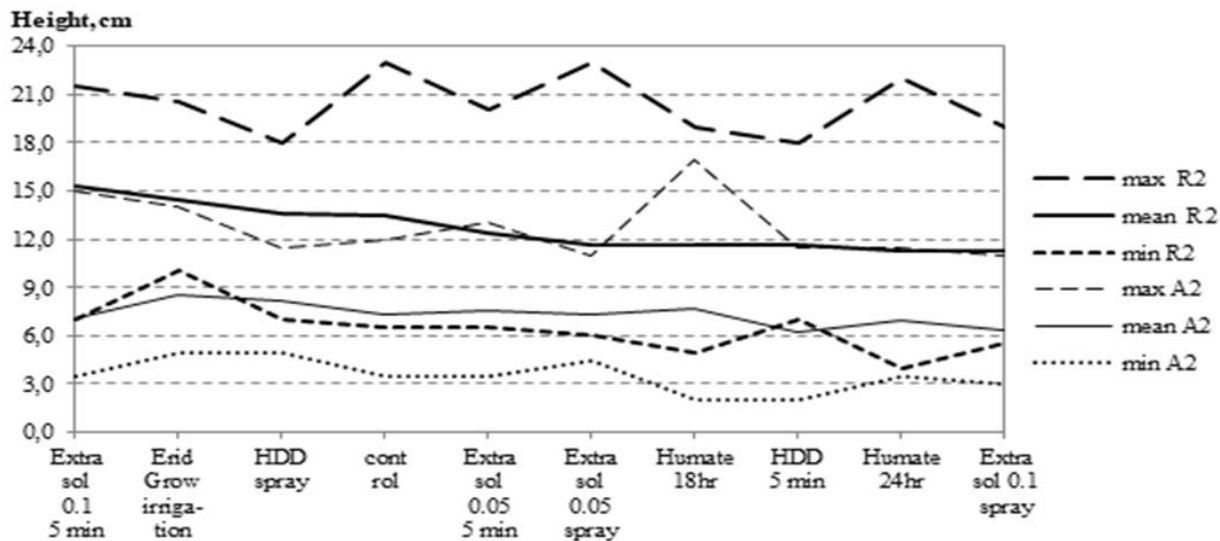


Table 5. Parameters of bootstrap distribution of pine's height in cm for the nursery SFNR "Ertis Ormany", the first year of plant life

	<u>Ex</u> <u>trasol</u> 0.05 spray	<u>Ex</u> <u>trasol</u> 0.1 spray	<u>Ex</u> <u>trasol</u> 0.1 5min	<u>Ex</u> <u>trasol</u> 0.05 5min	HDD spray	HDD 5min	<u>Erid</u> <u>Grow</u> <u>irriga</u> <u>-tion</u>	Hu mate 18hr	Hu mate 24hr	Contr ol
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's height in cm for the nursery SFNR "Ertis Ormany", the Second year of plant life

	<u>Ex</u> <u>trasol</u> 0.05 spray	<u>Ex</u> <u>trasol</u> 0.1 spray	<u>Ex</u> <u>trasol</u> 0.1 5min	<u>Ex</u> <u>trasol</u> 0.05 5min	HDD spray	HDD 5min	<u>Erid</u> <u>Grow</u> <u>iriga</u> <u>-tion</u>	Hu mate 18hr	Hu mate 24hr	Contr ol
Mean	11.30	15.11	11.28	11.69	11.71	13.52	14.56	13.63	12.41	11.58
Median	9	2	4	6	3	3	2	5	0	4
Mode	11.30	15.32	11.29	11.69	11.70	13.52	14.45	13.63	12.40	11.58
SD	9	8	3	7	1	4	0	9	9	7
	11.32	15.50	11.20	11.50	11.70	13.50	14.50	13.50	12.50	11.50
	0	0	0	0	5	0	0	0	0	0
	0.280	0.272	0.203	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

	<u>Ex</u> <u>trasol</u> 0.05 spray	<u>Ex</u> <u>trasol</u> 0.1 spray	<u>Ex</u> <u>trasol</u> 0.1 5min	<u>Ex</u> <u>trasol</u> 0.05 5min	HDD spray	HDD 5min	<u>Erid</u> <u>Grow</u> <u>irriga</u> <u>-tion</u>	Hu mate 18hr	Hu mate 24hr	Contr ol
Mean	2.789	2.629	2.634	2.678	2.831	2.726	2.829	2.980	2.569	2.480
Median	2.790	2.626	2.634	2.677	2.831	2.726	2.829	2.980	2.569	2.479
Mode	2.795	2.635	2.627	2.669	2.838	2.723	2.830	2.986	2.564	2.482
SD	0.050	0.051	0.052	0.056	0.054	0.050	0.059	0.062	0.051	0.063

Table 8. Parameters of bootstrap distribution of pine's height in cm for the nursery SNP "Kokshetau", the second year of plant life.

	<u>Ex</u> <u>trasol</u> 0.05 spray	<u>Ex</u> <u>trasol</u> 0.1 spray	<u>Ex</u> <u>trasol</u> 0.1 5min	<u>Ex</u> <u>trasol</u> 0.05 5min	HDD spray	HDD 5min	<u>Erid</u> <u>Grow</u> <u>irriga</u> <u>-tion</u>	Hu mate 18hr	Hu mate 24hr	Contr ol
Mean	7.739	7.063	6.350	6.977	7.262	7.337	8.587	8.139	7.562	6.257
Median	7.739	7.062	6.351	6.963	7.261	7.336	8.575	8.149	7.560	6.249
Mode	7.745	7.062	6.322	6.956	7.295	7.330	8.604	8.162	7.554	6.245
SD	0.189	0.166	0.117	0.116	0.098	0.124	0.126	0.138	0.154	0.165

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

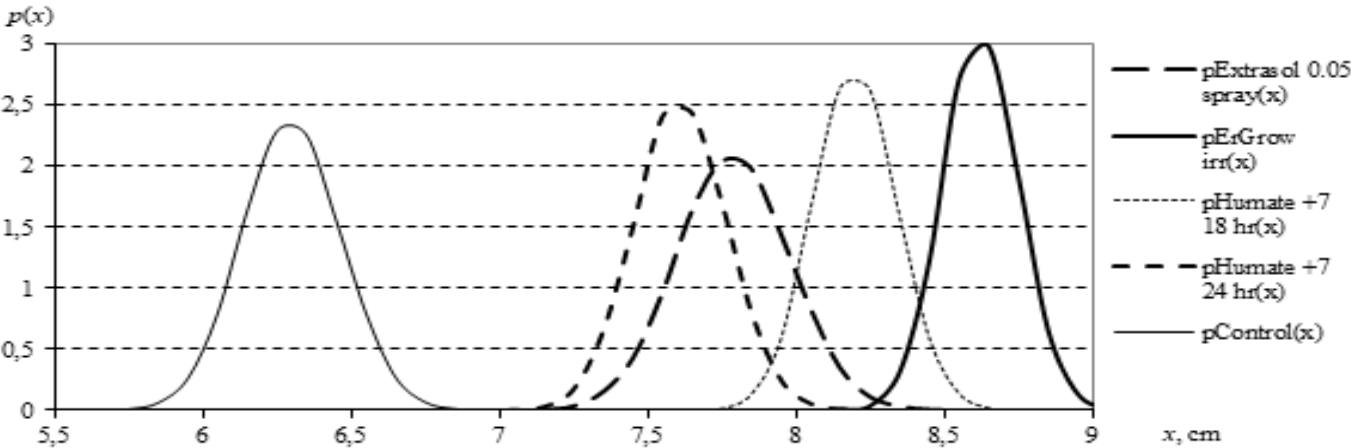
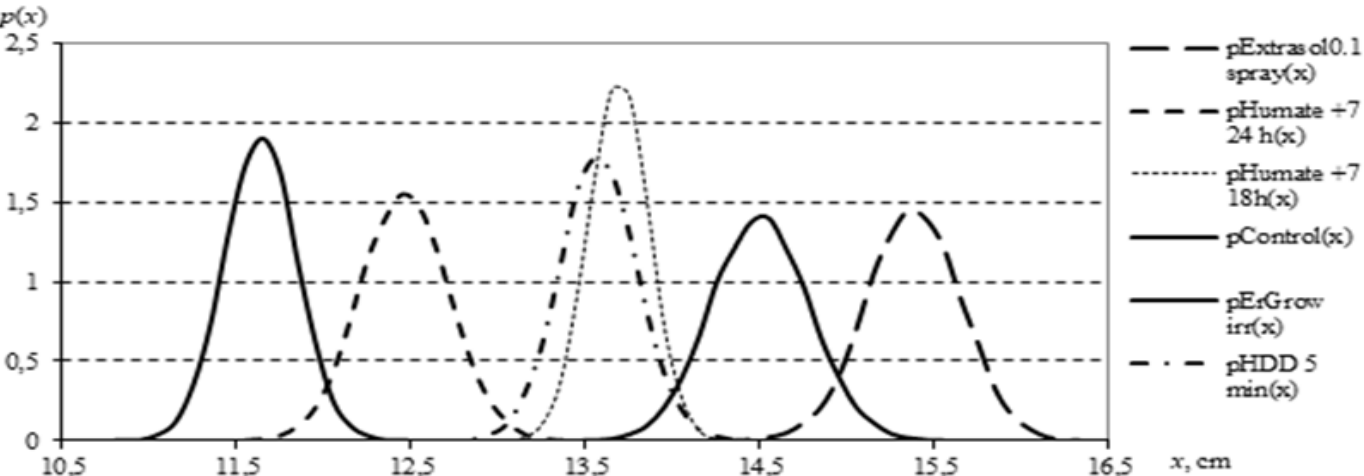


Figure 4. Densities of the normal distribution of the average height estimates obtained by the bootstrap method for pines of the second year of life, SFNR nursery “Ertis Ormany” (in cm)



$$F(x_q) = q. \quad (1)$$

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

$$\bar{X}^q = \frac{1}{N(N-1)} \cdot \sum_{i=1}^N \sum_{j=1, i \neq j}^N X_i \cdot \left(1 - \frac{(I(X_i < x_q) - q) \cdot (I(X_j < x_q) - q)}{q(1-q)} \right), \quad (2)$$

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

$$\text{Var}\{\bar{X}^q\} = \frac{\sigma^2}{N} - \frac{1}{N} E^2 \left\{ \frac{X \cdot (I\{X < x_q\} - q)}{q(1-q)} \right\} + O\left(\frac{1}{N^2}\right), \quad (3)$$

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

$$\sigma_q^2 = \lim_{N \rightarrow \infty} N \cdot \text{Var}\{\bar{X}^q\} = \sigma^2 - \left(\sqrt{\frac{1-q}{q}} \cdot \int_{-\infty}^{x_q} x dF(x) - \sqrt{\frac{q}{1-q}} \cdot \int_{x_q}^{+\infty} x dF(x) \right)^2, \quad (4)$$

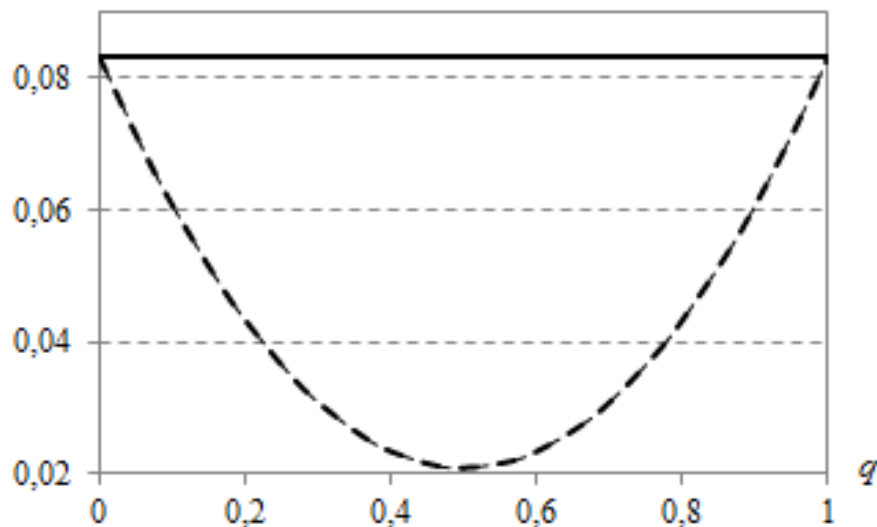


Figure 5. Dependency graph σ_q^2 from q and $\sigma^2 = 1/12$ for $F(x) = U_{(0,1)}(x)$

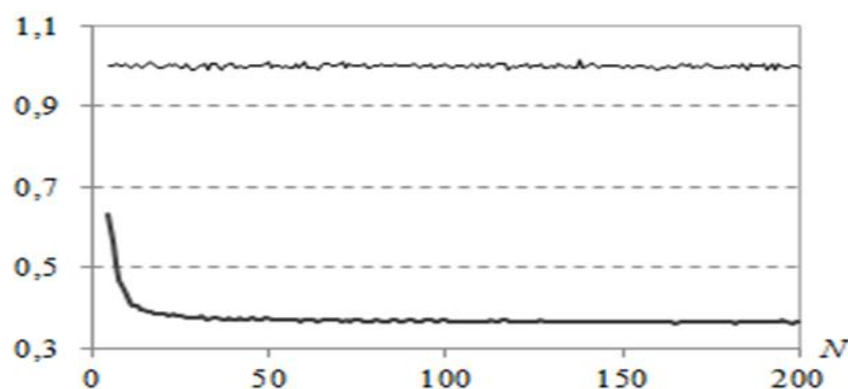


Figure 6. Values of stimulated $N \cdot \text{MSE} \{\bar{X}^q\}$ and $N \cdot \text{MSE} \{\bar{X}\} \approx 1$ depending on $N > 5$ for $F(x) = N_{(0,1)}(x)$, $x_q = 0$, $q = 0.5$, $R = 10^5$

Applying 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 obtained that $\bar{X}^q = 10.226$ cm, while $\bar{X} = 11.587$ cm, which is actually 1.361 cm less, which 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 $p_a(x)$ – for \bar{X}^q and $p(x)$ – for \bar{X} , obtained using bootstrap modeling with a modeling parameter $M=10^5$.

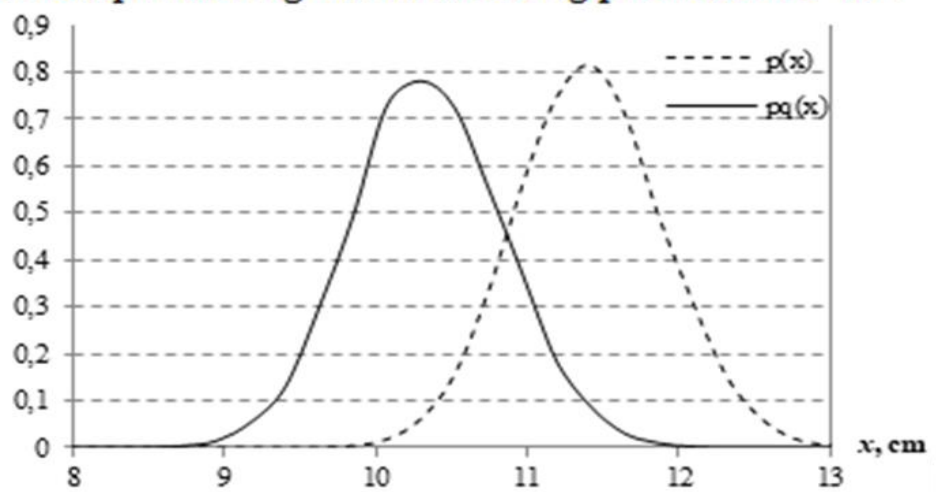


Figure 7. Distribution density charts $p_a(x)$ – for \bar{X}^q and $p(x)$ – for \bar{X} , obtained using bootstrap modeling with parameter $M=10^5$

Conclusion

- positively affects annual seedlings by increasing their average height.
- the results obtained vary by the region of the nursery location.

In the SNNP “Kokshetau”:

- The first –year old increased by 13.9%.
- the two–year–old seedlings increased by 37.2%.

in the SFNR “Ertis Ormany”

- 7% in the first year
- 24.7% in the second year.

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**Thank you
for your attention!**