Pre-sowing treatment of ROBINIA PSEUDOACACIA L. seeds with electric field of high voltage

Igor Yudaev¹, Denis Ivushkin², Maria Belitskaya³, Irina Gribust³

¹Azov-Black Sea Engineering Institute Don State Agricultural University, Lenina 21, Zernograd, 344470, Russia
²Volgograd State Agricultural University, prospekt Universitetskiy 26, 400002, Russia
³Federal State Budget Scientific Institution «Federal Scientific Centre of Agroecology, Complex Melioration and Protective Afforestation of the Russian Academy of Sciences», prospekt Universitetskiy 97, Volgograd, 400062, Russia

E-mail: IvushkinDS@yandex.ru

Abstract. Seed treatment before sowing is the basis for increasing sowing qualities, stable development and resistance of seeds to harmful organisms. Greening of production processes of forestry makes it necessary to find new methods of pre-planting treatment, which include electric impact on planting material. For the first time, materials are presented on the study of the effect of an electric field of high voltage alternating current on Robinia pseudoacacia L. seeds with the identification of optimal exposure modes that increase the sowing and growth properties of seeds.

1. Introduction
At the present stage, there is a significant deterioration of the state of recreational-greening planting of urban ecosystems and protective forest plantations of forest and agricultural landscapes. Under these conditions, it is particularly important to carry out measures for the reconstruction of green plantations using standard planting material, which is feasible if seeds with high planting qualities are used [1-5].

As is known, during long-term storage the seeds of wood plants lose germination quite quickly. Therefore, one of the pressing problems of forestry is to find effective ways to improve their quality [6-11]. At the present stage, new opportunities have emerged for the development of efficient and environmentally friendly ways to improve seed quality and growth of tree seedlings. For this purpose, various methods are used, among which the main role is played by stratification (snow retention) of seeds, use of soil-harvesting preparations, microbiological agents.

Recently, the possibilities of using physical methods, such as electric fields, have increasingly attracted the attention of researchers. It is known that the use of an electric field for the treatment of seed material increases yield. It has been proved that the treatment of seeds by this method increases their germination, positively affects the growth and development of plant objects [12-17].

The question of the influence of electric fields on wood seeds has not yet been studied [18]. This was the basis for our research. For the experiment, we took seeds of Robinia pseudoacacia L., which is widespread in protective plantations of various types of the Southern Federal District, a rapidly growing and long-lasting tree species.
2. Materials and methods

Treatment of seeds with electric field of alternating current of high voltage was carried out at installation consisting of commercially available Skat-70 apparatus, two plate electrodes arranged in experimental cell [19-22].

The Skat-70 apparatus is designed to test the electrical strength for alternating or constant voltage of various materials and devices. It is possible to use Skat-70 for test tests of samples of various solid dielectrics, including composite, various electronic components with high-voltage galvanic isolation, as well as other devices and their parts, where electric strength check is important. In our case, the apparatus was used as a source of adjustable AC high voltage up to 4 kV [19-22].

Robinia pseudoacacia seeds were placed in a uniform layer in an experimental cell on the lower electrode, the upper electrode being 15 cm from the treated seed layer. The external view of the research complex is shown in Figure 1.

In laboratory conditions, the most efficient pre-sowing treatment of seeds was searched by an electric field of high alternating voltage. The test scheme included the following options:

- Control - without processing;
- Reference - treatment of seeds with Zircon preparation
- 3-12. electric stimulation of seeds by electric field with value of 1, 2, 3, 4 kV and processing time of 60, 120 and 180 seconds.

Seeds after treatment were placed in sterile Petri dishes on a bed of wet filter paper to assess seed qualities. Germination energy was determined on day 5, laboratory germination on day 10.

3. Results and discussion

Studies have shown that the electric stimulation of Robinia pseudoacacia seeds in the electric field of high alternating voltage caused a good positive effect (Fig. 2).
Figure 2. Impact of electrical stimulation on germination energy and germination of Robinia pseudoacacia seeds, %.

The treatment of the sowing material of the high voltage AC electric field has a positive effect on germination energy and seed germination. As a result of the laboratory experiments carried out, it was noted that the rate and friendship of germination of wood seeds depends on the parameters of exposure - the time of treatment of the seed material. Thus, very high values of germination energy (5th day) are marked on the versions of application of AC electric field of high voltage 1 kV and 2 kV exposure 180 seconds (4.8% increase relative to control and 5.3% increase relative to reference), 3 kV exposure 120 seconds (10.0% increase relative to control and 3.5% increase relative to standard) and 4 kV exposure of 120 seconds (11.8% increase relative to control and 5.3% increase relative to standard).

It should be noted that in variants with 3 kV and 4 kV modes of 180 seconds exposure, seed germination energy was - 100% absolute.

Upon reaching 10 days (germination), similar high results were recorded. Options with 3 kV and 4 kV modes with an exposure of 180 seconds lead among the exposure modes used.

In the experimental versions, the value of these indices increased more in the versions with application of electric field of voltage 3 kV and 4 kV with exposure 180 seconds - by 13.5 and 8.2% compared to the control, 7.0 and 3.5% relative to the standard.

After the 21st day of laboratory experience, in order to detail the impact of different methods of pre-sowing treatment, Robinia pseudoacacia seeds were analyzed by the high-voltage AC electric field with changes in their main morphometric indices (Table 1).

The method of preparation of seeds for sowing revealed an ambiguous response of seedlings to the effect. The greatest effect is exhibited by treating seeds in the high voltage electric field with an exposure of 180 seconds. As efficiently as possible, the electric stimulation of R. pseudoacacia seeds affected the increase in the number of lateral roots of the seedlings, the number of which in the experimental versions increased by 7.3 ÷ 9.3 times relative to the control. The comparative estimate of the indicator with the reference version revealed a less pronounced effect - the number of lateral roots of seedlings increased only 1.9 ÷ 2.43 times. The average length of the lateral roots of the seedlings increased in 3.08 ÷ 4.7 times and 1.4 ÷ 2.21 times as compared to the control and the variant using the reference, respectively.

The length of the main root of the seedling under the action of the AC electric field of high voltage increased 2.8 ÷ 3.84 times as compared to that of the control version and 1.44 ÷ 1.98 times as compared to the reference.
The positive effect of electrostimulation is also noted on the length of the seedling stem, which increases 2.15 ÷ 3.38 times and 2.2 ÷ 3.48 times relative to the control and standard, respectively.

**Table 1.** Influence of different methods of pre-sowing treatment on morphometric indices of Robinia pseudoacacia seeds development.

| Indicator                                      | Control - processing steps | Zircon - standard |
|------------------------------------------------|---------------------------|-------------------|
| The length of the seedling stem, sm.           | 1.65                      | 2.53              |
| Length of the main root of the seedlings, cm.  | 1.47                      | 1.8               |
| Number of lateral roots of seedlings, pcs.     | 1.5                       | 8.0               |
| Average length of lateral roots of seedlings, cm. | 0.4                       | 1.0               |
| Number of first true leaves, pcs.              | 2.0                       | 2.0               |

**High voltage AC electric field**

| Processing time, sec. | 50 | 100 | 150 | 50 | 100 | 150 | 50 | 100 | 150 | 50 | 100 | 150 |
|-----------------------|----|-----|-----|----|-----|-----|----|-----|-----|----|-----|-----|
| 1 kV                  | 2.98 | 2.78 | 3.55 | 3.05 | 3.00 | 3.05 | 3.00 | 3.05 | 3.00 | 3.05 | 3.00 | 3.05 |
| 2 kV                  | 2.17 | 2.57 | 4.12 | 4.12 | 4.12 | 4.12 | 4.12 | 4.12 | 4.12 | 4.12 | 4.12 | 4.12 |
| 3 kV                  | 5.85 | 5.85 | 5.85 | 5.85 | 5.85 | 5.85 | 5.85 | 5.85 | 5.85 | 5.85 | 5.85 | 5.85 |
| 4 kV                  | 3.72 | 3.72 | 3.72 | 3.72 | 3.72 | 3.72 | 3.72 | 3.72 | 3.72 | 3.72 | 3.72 | 3.72 |

The electrical impact on R. pseudoacacia seeds of the appearance of the first true leaves and the increase in their quantity is weakly expressed.

Our experiment to assess electrical stimulation on morphometric indicators of seeds confirms the opinion of researchers on the positive impact of high voltage electric field on plants. Preparation of seeds for sowing by electrical stimulation shows a positive result, significantly increasing their germination and growth strength of seedlings. High values of basic indicators of seed development are caused by acceleration of biological processes in seed due to obtaining additional energy during treatment [14, 12].

It should also be noted that throughout the experiment, the seeds in the control variant were severely affected by fungal diseases. Electric field treatment contributed to reduced infection, resulting in more germinated seeds and faster seedling growth (Figure 3).
High voltage AC electric field

exposition 60 sec  exposition 120 sec  exposition 180 sec

Figure 3. Robinia pseudoacacia seeds contamination rate with phytopathogens on the 5th germination day.

4. Conclusions

The following conclusions can be drawn from the studies:
- The effect of the high voltage electric field on the seeds of Robinia pseudoacacia L. in general positively, their qualitative indices (germination energy and germination) are significantly increased;
- High voltage electric fields reduce the degree of infection with phytopathogenic fungi.
- Seeds that have initially high germination indices react to treatment with electric field of high voltage ambiguous, qualitative indicators can both increase and decrease.

In general, it can be stated that pre-sowing treatment of seeds with an electric field is useful to improve their sowing qualities. The proposed pre-planting treatment regimes have proved positive in laboratory conditions, which allows hoping for positive results in the field conditions in the production of wood planting material.

Based on the results of the study, new methods have been developed for intensive agricultural technology for growing planting material, which can complement the technologies already used in farms.

References

[1] Vereshchagin A, Khmeleva A 2010 Influence of ultra-sound radiation and growth regulators on rhizogenic activity of plant objects: monograph (Biysk: Ed-vo Alt. State technical. Un-t) p 73
[2] Cierjacks A, Kowarik I, Joshi J, Hempel S, Ristow M, Weber E 2013 Journal of Ecology 101 pp 1623 – 1640
[3] Wang L, Dai Y, Sun J, Wan X 2017 Trees - Structure and Function 31 6 pp 2011 – 2021
[4] Orekhova T 2010 Coniferous/Boreal Zone XXVII 1-2 pp 25 - 31
[5] Pentelkina N 2012 Current problems of the forest complex (Bryansk: BGITA) pp 189 – 193
[6] Timofeeva V, Golovchenko L, Panteleev S 2018 State and prospects for the development of green construction in the Republic of Belarus. Theses of the Republican Scientific and Practical Seminar (Minsk: Medisont) pp 179 - 182
[7] Hinchuk D 2014 Forest journal 6 pp 55 – 61
[8] Commissarov G 2006 Reports of the Academy of Sciences 406 1 pp 108 – 110
[9] Tabatabaei S 2015 Cercetări Agronomicicein Moldova XLVIII 2 162 pp 61 – 67
[10] Borges C, de Lima e Borges E, de CarvalhoGońçalves J, Bras S 2010 Sementes 32 3 pp 152 – 162
[11] Nagel M, Rehman M, Rosenhauer M, Börner A 2009 Tagung der Vereinigung der Pflanzenzüchter und Saatgutkaufleute Österreichs 1 2 pp 179 – 182
[12] Azarov E, Dvuhvatski A, Shuvalov A, Yudaev I, Gribust I, Belitskaya M 2009 Energy-saving
technologies. Challenges to their effective use: Proceedings of the II International Scientific and Practical Conference (Volgograd: VGSHA) pp 104 - 108

[13] Aksenov M 2016 Electrotechnology, optical radiation and electrical equipment in the agricultural complex: materials of the international scientific and practical conference dedicated to the memory of the leading electrotechnologist of Russia academician Ivan Fyodorovich Borodin (Volgograd: Publishing House Volgograd State Agrarian University) pp 26-33

[14] Belitskaya M, Gribust I, Azarov E, Yudaev I 2013 Energetiki automatics. Science Journal 3 pp 48 - 54

[15] Kazakova A, Yudaev I, Fedorishchenko M, Mayboroda S, Ksenz N, Voronin S 2018 Journal of Biological Sciences 18 2 pp 197 – 207

[16] Akdemir Evrendilek G, Tanasov I 2017 Seed Science & Technology 45 1 pp 1 – 9

[17] de Sousa Araujo S, Paparella S, Dondi D, Bentivoglio A, Carbonera D, Balestrazzi A 2016 Front Plant Sci. 7 1 pp 646 – 658

[18] Ling Ya, Hai-long Sh 2011 Journal of Forestry Research 22 1 pp 2 – 34 DOI 10.1007/s11676-011-0120-9

[19] Aksenov M 2016 Strategic guidelines of innovative development of agro-industrial complex in modern economic conditions: materials of the international scientific and practical conference (Volgograd: Publishing house Volgograd State Agrarian University) pp 335 - 339

[20] Ivushkin D, Khan V, Kostychev K 2017 Integration of science and practice in modern conditions: materials of the IX International Scientific and Practical Conference pp 100 - 106

[21] Kostychev K, Storozhakov S, Ivushkin D 2017 Science in the modern world. Proceedings of the XXIX International Scientific and Practical Conference (Center for Scientific Thought) p 199-203

[22] Starodubtseva G, Livinskiy S, Gabriyelyan S, Lubaya S, Afanacev M 2018 Acta Technologica Agriculturae 1 3 pp 28 – 32