Publ. Astron. Obs. Belgrade No. 102 (2022), 175 - 178 *Contributed Paper*

THE EFFECT OF PLASMA SEED TREATMENT ON GERMINATION AND EARLY GROWTH OF *THUJA KORAIENSIS* NAKAI PLANTS

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Abstract. Seeds of *Thuja koraiensis* Nakai widely used in decorative gardening and landscaping were treated with radio frequency (RF) and dielectric barrier discharge (DBD) plasmas to enhance germination, improving the morphometric parameters and to obtain possible selective samples for subsequent breeding of ornamental species. Plasma seed treatment reduced the period of seed germination, significantly increased the average root length - by 75% for RF plasma treatment and by 175% when exposed to DBD plasma and induced morphological changes in seedlings.

1. INTRODUCTION

At present, the non-thermal plasma surface activation of seeds is increasingly being explored in the agricultural field as an effective pre-sowing treatment enhancing seed germination and plant growth, providing a certain degree of seed decontamination, see reviews Sera et al. 2018, Waskov et al. 2021. The authors mainly report on the short-term effects of plasma seed treatment at the juvenile stage of annual plants in laboratory conditions. However, only a few papers are known on the response of perennial species to plasma seed treatment [Puac et al. 2005, Mildaziene et al. 2016, Pauzaite et al. 2017, Ling Li et al. 2021]. Nevertheless the role of perennial ornamental plants, landscaping techniques in optimizing the living environment of the urban population is increasing, which requires new approaches to landscaping, taking into account the increasing anthropogenic pressure on plants.

Modern breeding of ornamental plants is based on the use of several basic approaches: selection among seedlings of specimens that differ in a number of characteristics from the original mother plant; vegetative propagation of mutations arising on plants; the effect on seed or vegetative material of chemical or physical mutagens, etc.

In this paper, we aimed at cold plasma application for seed treatment of perennial ornamental plant *Thuja koraiensis* Nakai to increase the germination, as well as to detect possible mutational changes in plants for obtain new breeding varieties.

2. EXPERIMENTAL SECTION

1. 1. PLASMA SETUPS FOR SEED TREATMENT

We used two plasma systems for seeds treatment: low pressure radio frequency (RF) discharge (RF plasma) as well atmospheric pressure dielectric barrier (DBD) discharge (DBD plasma).

RF plasma treatment was carried out in a planar geometry capacitively coupled 5.28 MHz plasma reactor consisting of two plane-parallel electrodes placed in a vacuum chamber [Filatova et al. 2020]. Voltage was applied to the upper electrode. Petri dish with seeds was placed on a lower electrode. Before igniting the discharge, the air was pumped from the chamber for about 7 min to reach the working pressure 200 Pa. The input power was 8.4 W.

DBD plasma ignited between two round electrodes separated from each other by a distance of 3 mm [Savastenko et al. 2022]. The upper mesh electrode with 98 mm diameter was covered by 2.0 mm quartz glass layer and connected to an alternating current power source. The lower plate electrode made of copper was grounded. The applied voltage (peak-to-peak value) was up to 25 kV with a frequency of 1 kHz. The samples to be treated were put on the grounded electrode. The power was not more than 6.2 W.

Treatment duration with both RF and DBD plasmas was 7 min.

2. 1. PLANT MATERIAL AND METHODS

Seeds of *Thuja koraiensis* Nakai harvested in the third decade of August 2021 were collected from the Central Botanical Garden of the National Academy of Sciences of Belarus (Minsk, Belarus).

The effect of treatment was assessed by seed germination tests in laboratory conditions which were started one day after the treatment. Control (untreated) and treated with RF and DBD plasmas seeds (three replicates of 100 seeds each variant) were placed in Petri dishes which were put in a climatic chamber (KK 750, POL-EKO-APARATURA, Poland) with constant light and temperature conditions (light: for 16 h at 27 ºC, darkness: for 8 h at 20°C). Seed germination was monitored for 15 days.

Then seedlings were planted in containers and placed in a heated greenhouse with a round-the-clock temperature of 22 ºC for future observation.

3. RESULTS AND DISCUSSIONS

It was found that plasma treatment had a stimulating effect on the germination of *Thuja koraiensis* Nakai seeds (Figure 1a). The treatment with RF and DBD plasmas increased the germination rate by 9.4 and 10.8% respectively, which is two times higher than in control. The treatment also affected the dynamics of germination and shortened the period of germination of the bulk of the seeds. The vast majority of plasma treated seeds germinated on the 12th day. In the control variant, less than half of seeds sprouted within the specified time periods, and the peak of seedlings occurred on the 13-14th day. The root growth parameters significantly improved in response to the cold plasma treatment. The average root length increased by 75% for RF plasma treatment and by 175% for DBD plasma (Figure 1b).

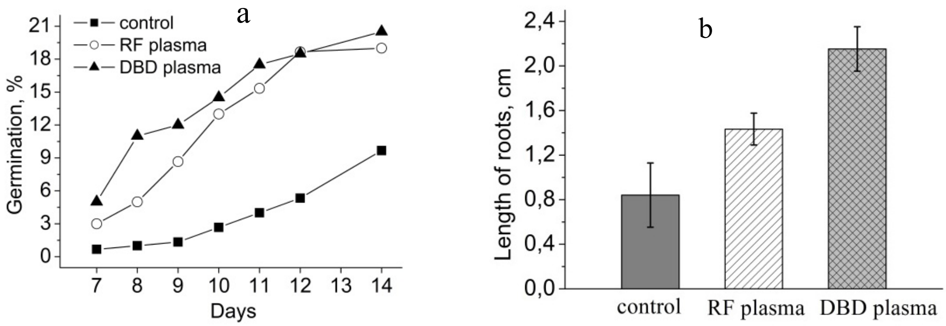

Figure 1: Germination dynamics (a) and the average root length (b) of control and plasma treated seeds of *Thuja koraiensis* Nakai.

During further observations of seedlings grown in containers in a greenhouse, samples with variegated color of needles, as well as with abnormal branching, were observed (Figure 2). It is noteworthy that the first type of anomalies in the control was encountered sporadically, the second was not detected.

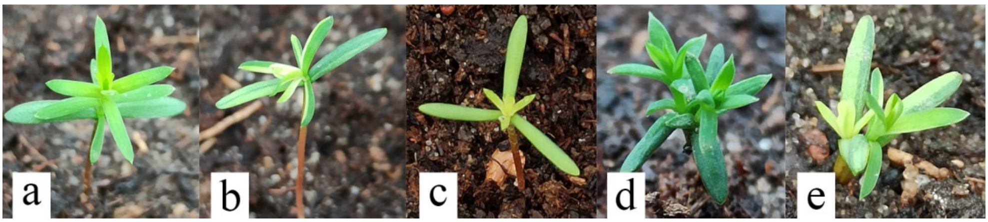

Figure 2: Seedlings of *Thuja koraiensis* Nakai (8 weeks old) in control (a) and in variants of plasma seed treatment with some morphological changes: milky white patches on the needles (b), more yellow color of the needles (c), two central shoots (d), two central shoots and milky-white patches on the needles (e).

Pauzaite et al. 2017 reported that pre-sowing treatment of Norway spruce (*Picea abies* (L.) Karst.) seeds with RF plasma had positive effects on plant development during the later stages, even despite some negative effect of treatment on seed germination. On a longer time scale (17 months after sowing) the plants of Norway spruce grown from the plasma treated seeds (during 5 and 7 min) were higher by 50–60% and had more branches (40–50%) in comparison to the control seedlings. A similar result was obtained on other perennial woody plant species − *Morus nigra* L. and *Rhododendron Smirnowii* Trautv. [see Mildaziene et al. 2016]. Seedlings of these perennials from RF plasma treated groups where inhibition of germination was the strongest also showed the best growth in later stages of development. The most negative stressor effects on seed germination were followed by the most rapid leaf growth possibly due to stress-induced stem branching. Besides, plants grown from seed treated with RF plasma showed various degrees of early branching. The most effective in causing branching was long-duration regime of RF plasma treatment (7 min): more than 30% of plants developed more than one stem, two plants had three stems, and one plant had four stems. The degree of branching correlated well with differences in numbers of leaves and total leaf surface area.

The results obtained in this paper also indicate that both RF and DBD plasma treatment of seeds can induce similar types of anomalies in *Thuja koraiensis* Nakai which may survive or even intensify in subsequent stages of plant growth.

4. CONCLUSIONS

It has been shown that plasma treatment of seeds of *Thuja koraiensis* Nakai significantly accelerates and increases germination, and also stimulates root growth. Seedlings with abnormal color of needles and shape of habitus were noted. If this trait is preserved during a longer observation, this will allow us to recommend plasma seed treatment as a new effective and ecologically friendly method for the selection of *Thuja koraiensis* Nakai plant.

References

Sera, B., Sery, M. : *Plasma Sci. Technol.* 2018, **20,** 04401.
Waskow, A., Howling, A., Furno, I. : 2021, *Front. Phys.* **9**, 617345.
Puac N., Petrovic Z., Zivkovic S, et al.: 2005, *Plasma Processes and Polymers*, eds. R. d'Agostino, P. Favia, C. Oehr and M.R. Wertheimer, Whiley, 193-203.
Mildaziene Pauzaite, G.et al. : 2016, *Bioelectromagnetics*, **37**, 536.
Pauzaite, G., Malakauskiene, A. et al.: 2017, *Plasma Process Polym.*, e1700068.
Ling Li, Jingbo Chen, et al. : 2021, *Crop Science*, **61**(4), 2827.
Filatova, I., Lyushkevich, V. et al.: 2020, *J. Physics D: Appl. Phys.*, **53**(24), 24400.
Savastenko, N., Shcherbovich, A. et al.: *High Temp. Mater. Process*, **26**(2), 25.