Investigation of treatment of wheat seed by plasma of dielectric coplanar surface barrier discharge

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Abstract: In this paper, we studied the effects of plasma treatment of wheat seeds on germination and α-amylase enzyme activity. In order to characterize the plasma the optical properties of the dielectric coplanar surface barrier discharge (DCSBD) were investigated. The results showed that the plasma of DCSBD has a positive effect on germination rate of wheat seed sand α-amylase enzyme activity during the growth. Also, the biometric indicators of germinated seeds were significantly higher after the plasma processing.

Keywords: plasma treatment, dielectric coplanar surface barrier discharge, wheat seed, α-amylase.

1. Introduction

The development of the agroculture in the world is connected with the new technologies necessary for growing and storing seeds. According to research by a number of scientists, atmospheric plasma DCSBD can affect the germination of seeds of agricultural crops as follows: disinfecting seeds by deactivating harmful microorganisms and bacteria [1,2], making changes in the surface structure of seeds, promoting water absorption by seeds [3],changing the chemical composition of the treated samples by introducing radicals [4,5].Enzymes play a key role in the germination of plant seeds. These substances have the ability to cause and accelerate chemical reactions occurring in living organisms. Scientists are researching one of the types of enzymes that catalyze the hydrolysis reaction, otherwise hydrolase. This includes the enzyme alpha-amylase, under the action of which starch hydrolysis occurs with the formation of dextrins and maltose, which affects the further growth of plants.

The relevance of this work is to study the activity of alpha-amylase in the treatment of plasma DCSBD, since the activity of alpha-amylase is one of key factor in the growth of the embryo and the subsequent germination of the plant.

2. Experimental setup

The experiments were carried out on the commercially available installation of a dielectric coplanar surface barrier discharge - Roplass RPS400 [6].

The chemical composition of the plasma was determined using optical emission spectroscopy. In the emission spectrum of DCSBD, molecular nitrogen bands were observed, namely, the second positive (N2 (C-B)) and the first negative (N2 + (B-X)) systems. In fig. Figure 1 shows the emission spectrum of a DCSBD in the 300-470 nm wavelength [7].

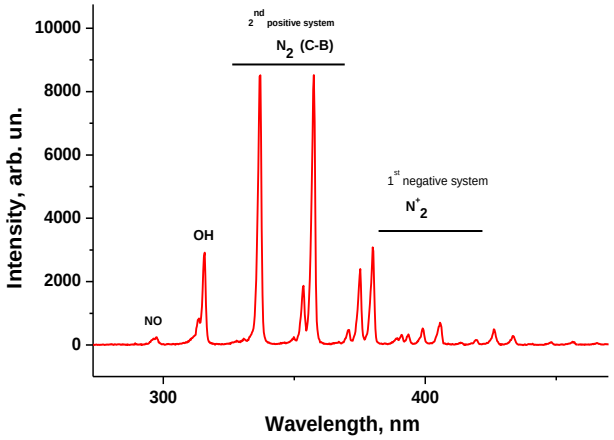

Fig. 1. The emission spectrum of the DCSBD in the wavelength range of 300–470 nm.

A number of experiments were also conducted to measure the surface temperature of the experimental setup. The results showed that when the DCSBD surface was completely filled with microdischarges, the temperature was 58°, which guarantees the absence of a thermal effect when wheat seeds are treated with DCSBD plasma.

3. Results and discussion

The effect of plasma on the germination of wheat seeds varied depending on the time duration of treatment (Fig. 2).The germination of seedfor 5, 10 and 15 seconds was 100, 96 and 98%, respectively. A significant difference was observed between the treated and control variants (7–12%) ($p < 0.05$).At the same time, there were no significant differences between the results obtained by plasma treatment for 5, 10 and 15 seconds. Processing grain of wheat for 30 seconds and above led to a complete stop of plant growth (data not shown).

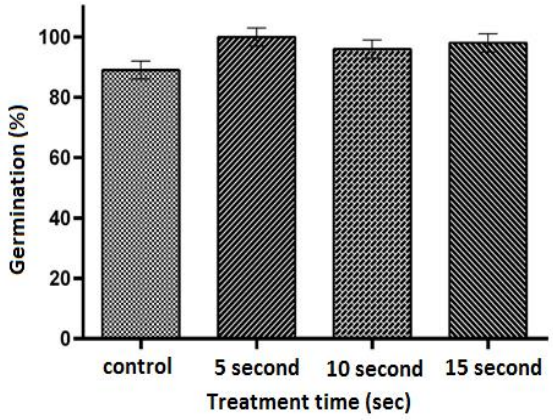

Fig. 2. The effect of plasma on the germination of wheat.

The results of wheat seed treatment experiments showed that seedlings of spring wheat, whose seeds were treated with plasma, had a mass of approximately 15–18% higher than untreated plants.The increase in the aboveground biomass of spring soft wheat plants ranged from 22% to 44%, while the weight of the root system increased from 60% to 80% per 1 plant.It should be noted that in the presented experiment, the options of treating plants for 15 seconds had the advantage. To determine the effect of plasma on the growth of seedlings, the following experiments determined the length of the root system and the first true leaf (shoot) at the age of 4 days. Fig. 3 shows the biometric indicators of wheat seedlings after plasma treatment.

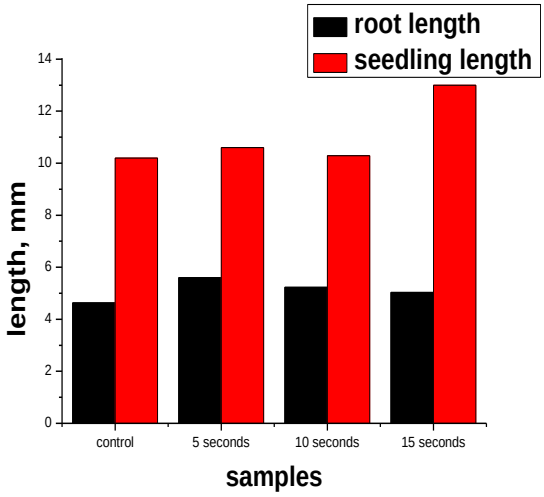

Figure 3. Biometric indicators of wheat germ after plasma treatment.

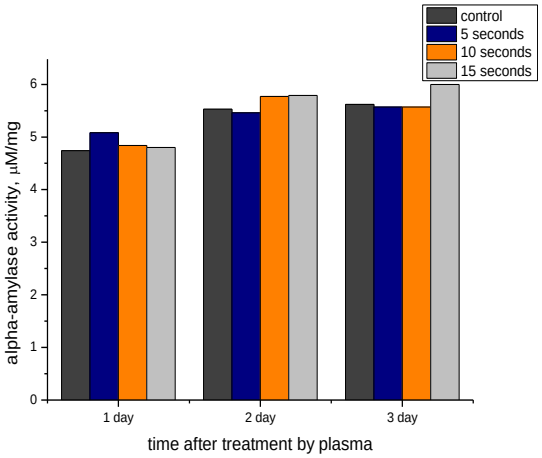

Figure 4. The method of checking the activity of alpha-amylase by the method of "DNS".

The present study showed that plasma has a positive effect on the germination of wheat grain. Grain germination and biometric indicators were significantly higher during plasma processing.The efficiency depended on the duration of plasma action. Treatment of seed for 15 seconds caused the greatest stimulating effect on the germination and biometric indicators of the wheat germ.The plasma treatment process probably provides water absorption and activates enzymatic and other biological reactions in the plant cell, which leads to more rapid and uniform germination.The method of analyze the activity of the enzyme alpha-amylase by the "DNS" method showed that the highest activity of alpha-amylase on the first day is achieved with a plasma treatment of 5 s, and on the second and third days with a plasma treatment of 15 seconds (Fig. 4).As mentioned above, alpha-amylase activity is a key factor in the growth of the embryo and further germination of the plant, therefore, the highest alpha-amylase activity contributes to the best seed germination, and the atmospheric pressure plasma treatment of seeds gives the best result compared to the control sample.

Acknowledgments

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References

[1] M. Ito, J.-S. Oh, T. Ohta, M. Shiratani, M. Hori, doi.org/10.1002/ppap.201700073 (2017).

[2] S. Mošovskáa, V. Medvecka, N. Halaszova, P. Durina, L. Valik, A. Mikulajova, A. Zahoranová, Food Research International, **106**, 862–869 (2018).

[3] Y. Park, K. Suk Oh, J. Oh, Plasma Process Polym, doi.org/10.1002/ppap.201600056 (2016).

[4] M. Henselová, L.Slováková, M.Martinka& A. Zahoranová, Biologia.) **67**, 490 – 497, (2012).
[5] L. Ling, L.Jiangang, Sh. Minchong, Scientific Reports. **5**, 13033, (2015).
[6] Vlasta Štěpánová, Pavel Slavíček, Mirko Černák. Plasma Process Polym. e1700076, (2017).
[7] A.K. Akildinova, Y.A. Ussenov, A.S. Pazyl, Rec. Contr. Phys. **2**, 58-65, (2018) (in russian).