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Use of electrostatic field to increase germination rate of rapeseed (*Brassica napus L.*)

Abstract. *The paper presents the results of research on increasing the germination rate of rapeseed with the use of an electrostatic field. The electrostatic field is generated by the voltage bifilar winding. The seeds are exposed to an electrostatic field from a few to several seconds, while the bifilar winding is powered with a DC voltage in the range of 0-10 kV. The conducted research shows that the exposure of rapeseed to the electrostatic field causes a change in germination rate.*

Streszczenie. *W pracy przedstawiono wyniki badań dotycząc zwiększenia siły kiełkowania nasion rzepaku przy pomocy pola elektrostatycznego. Pole elektrostatyczne wytwarzane jest przez uzwojenie bifilarne napięciowe. Nasiona poddawane są ekspozycji na pole elektrostatyczne od kilku do kilkunastu sekund, natomiast uzwojenie bifilarne zasilane jest napięciem stałym z zakresu 0-10 kV. Z przeprowadzonych badań wynika, że ekspozycja nasion rzepaku na działanie pola elektrostatycznego powoduje zmianę szybkości kiełkowania (**Wykorzystanie pola elektrostatycznego do zwiększenia szybkości kiełkowania nasion rzepaku (Brassica napus L.)**)*

Keywords: electrostatic field, rapeseed, germination rate
Słowa kluczowe: pole elektrostatyczne, nasiona rzepaku, siła kiełkowania.

Introduction

Rapeseed is one of the most important oil crops in Poland and in the world. Its seeds are used in many industries, including the production of oil or as animal feed [1]. Rapeseed has several characteristic parameters. One of them is humidity, which determines the possibilities of its storage. Another parameter that tells about the condition of the seed is the germination rate, which is the main parameter in the case of seed material. Determination of germination capacity in accordance with the PN-R-65950 standard consists in determining the percentage of the number of seeds producing plants classified as ordinary (the appropriate development phase in a given time). Determination of germination capacity is intended to obtain information about the sowing value of a given batch of material, so that it is possible to compare them with other batches. Germination capacity is understood as obtaining the appropriate appearance of the plant at a certain time, which is a prognosis for its further proper development.

The possibility of influencing the germination rate is particularly important in the case of periodic water shortages. One can then accelerate the germination of seeds to make the most of the water available in the soil. Various methods are described in the literature to increase the germination rate. In work [3], rapeseed were immersed in a 0.8% NaCl solution and 0.8% KNO_3. The seeds were then washed with water. It was noted that the germination rate increased significantly after KNO_3 seed treatment. In turn, in study [4] rapeseed were conditioned with aqueous solutions of ascorbic acid (10 mM), L-cysteine (10 mM) and triacontanol (1 µM). Here, too, it was noted that treating the seeds in aqueous solutions improves the germination parameters of seeds. Further, in [5], the seeds were hardened by cyclic moistening and drying before planting. This treatment was aimed at increasing the seed tolerance to drought conditions. Another method, proposed in [6], is the treatment of rapeseed with the fungus *T. harzianum* from the Trichoderma family. Improvement of seed germination conditions was also observed here. A similar experiment was presented in [7]: rapeseed were treated with urea, potassium nitrate (KNO_3) and polyethylene glycol (PEG). In [8] it was observed that Condensed molasses soluble (CMS) is rich in minerals. Using it in small concentrations (0.05 g L-1) as a fertiliser, can increase the germination rate as well as the weight gain of plants. However, at too high concentrations, a negative effect of CMS on the germination rate was observed.

A popular method of supporting plant growth is the use of low-temperature plasma. In work [9] this phenomenon was used to accelerate the growth of tomatoes. There are more and more studies that use plasma-activated water. Depending on the type of discharge and gas used, activated water may contain active particles, e.g. dissolved ozone or hydrogen peroxide [10, 11]. Studies using plasma-activated water were also conducted on rapeseed. These studies are described in [12].

To increase the germination rate, electrostatic methods are used [13, 14]. They consist in placing the seeds between the electrodes, which are powered by a high DC voltage of several dozen kV [15]. In work [16], an AC power supply with a frequency of 50 Hz and a voltage of up to 5 kV was used. It was observed that the combination of the voltage value and the time of exposure of tomato seeds to the electric field makes for germination improvement. The effect of the electrostatic field on the germination of soybean seed at voltages of several volts is presented in [17, 18]. In these works, two parallel plates, made of aluminium foil and spaced 10 mm apart, were used. They were powered with a DC voltage of 3, 6, 9 V. In the above works, it was also observed that the increase in the germination rate is observed through the appropriate combination of voltage and time of exposure to the electrostatic field.

The reference method of germination rate estimation is the one described in the PN-R-65950 standard. This method is time-consuming, because it requires sowing seeds and waiting for seedlings to grow. An attempt to read the germination rate immediately was proposed in [19], where the signal generated by a piezoelectric plate when rapeseed hit it was used. This method is sensitive to seed moisture, so the results can be ambiguous.

The aim of the work is to investigate the possibility of increasing the germination rate of rapeseed by applying an electrostatic field generated by a voltage bifilar winding.

Materials and Methods

Rapeseed of the Bellevue variety harvested in the 2022 season were used as the research material. Seed moisture content was 7.55%. To increase the germination force, a voltage bifilar winding was used as a source of electrostatic field (Fig. 1), the winding was powered with DC voltage.

Fig.1 View of the voltage bifilar winding

A non-uniform electrostatic field is generated around the winding, the value of which is the highest at the contact of the windings (Fig. 2).

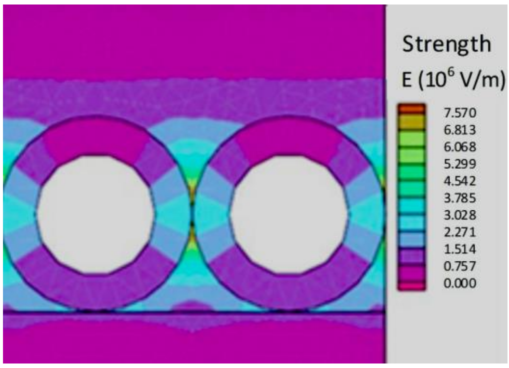


Fig. 2. Electrostatic field strength distribution around the bifilar winding [20]

Rapeseed were exposed to the electrostatic field, changing its parameters, e.g. bifilar winding supply voltage (0-10 kV) or exposure time (2, 4, 6, 8, 10, 12s). The measuring stand is shown in Figure 3.

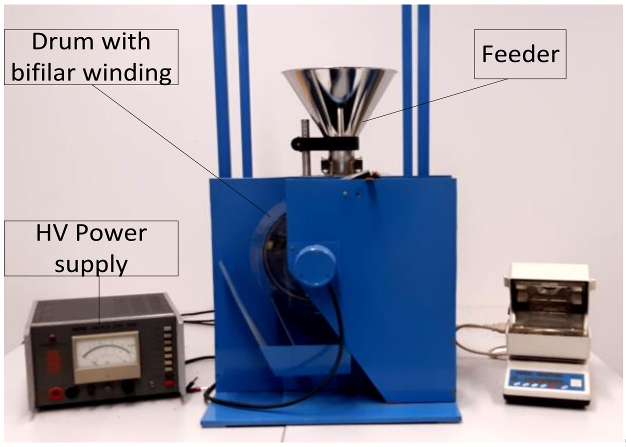


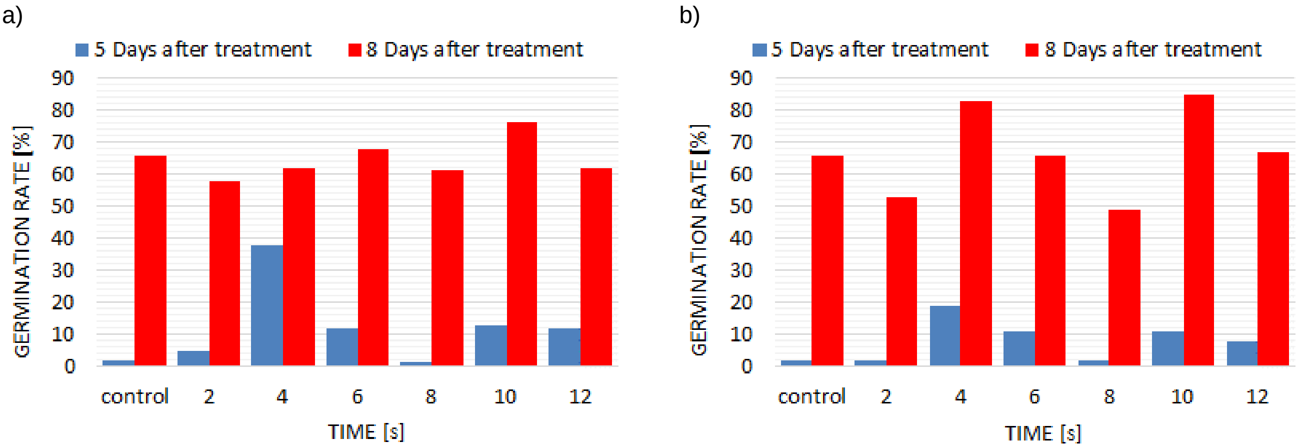
Fig.3. Experimental set-up

The power supply type P435 was used as the source of the electrostatic field. The drum on which the bifilar winding was wound had the following dimensions: radius R = 100 mm, the drum width was 65 mm. The bifilar winding is wound with a DY 0.5 mm^2 wire, the actual insulation thickness for this wire is 0.5 mm. By adjusting the rotational speed of the drum, the time of exposure of the electrostatic field to rapeseed was changed.

Rapeseed from the feeder were placed on a rotating drum on which a bifilar winding was wound. After this treatment, rapeseeds were placed in Petri dishes which were lined with lignin. The lignin was then moistened with water. Petri dishes with seeds were placed in a sunny place at room temperature. Then the growth of rapeseed lings was observed.

Results and discussion

The next step was to test the germination rate of rapeseed. This test was performed in accordance with the PN-R-65950 standard. Seeds that reached the correct growth phase were removed from the plates so as to leave space for the remaining ones. In order to be able to determine the average value, the tests were repeated three times for each sample. The control sample consisted of seeds not exposed to the electrostatic field. The research consisted in examining the effect of exposure time to the field and the value of the electrostatic field intensity on the germiantion rate of rapeseed. The test results are shown in Figure 4.



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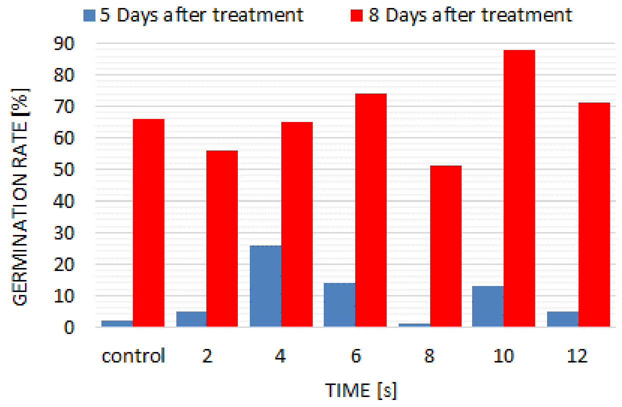

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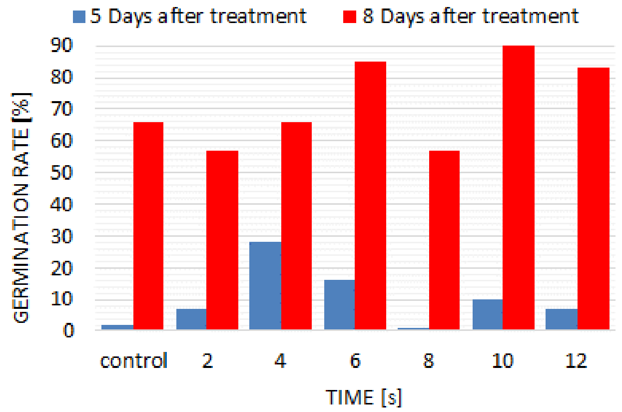

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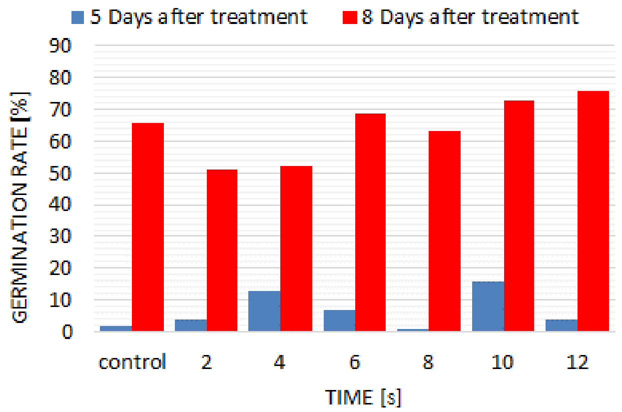

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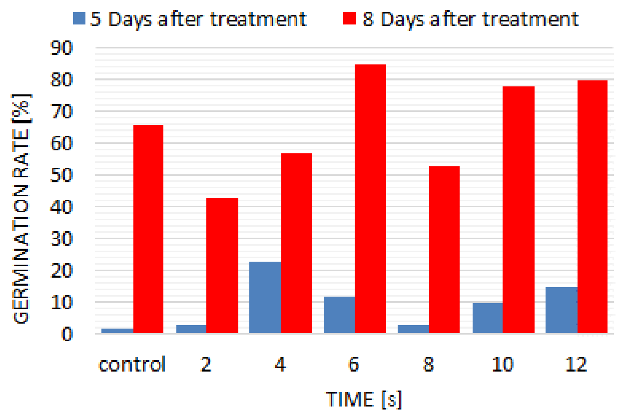

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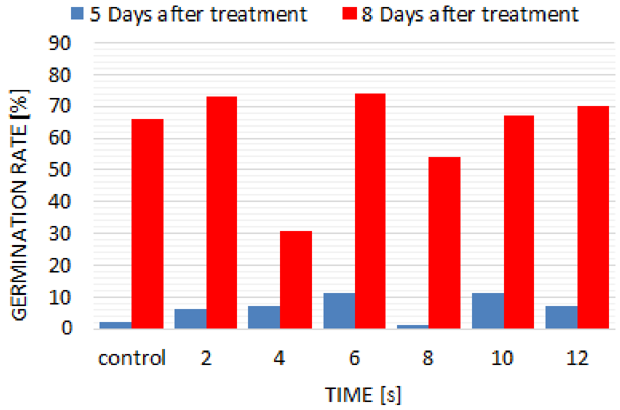

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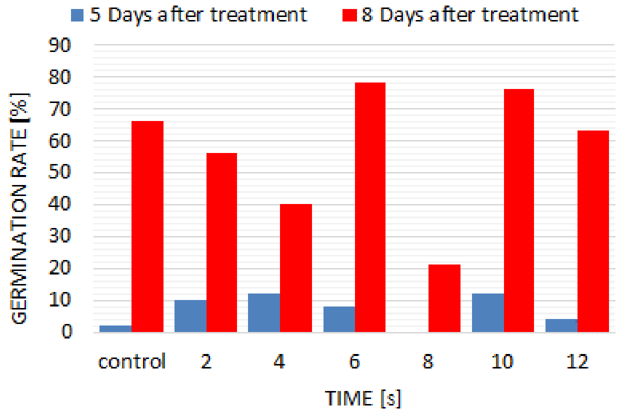
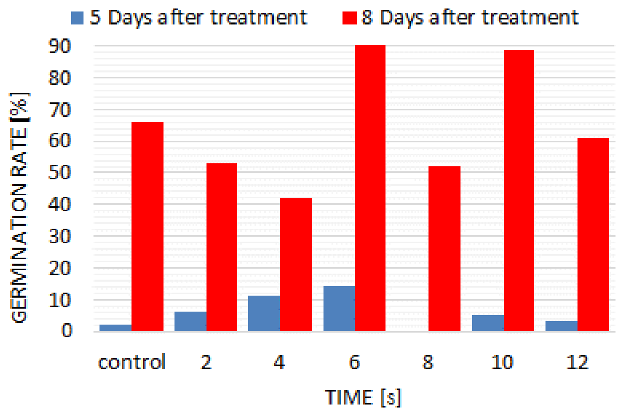


i)



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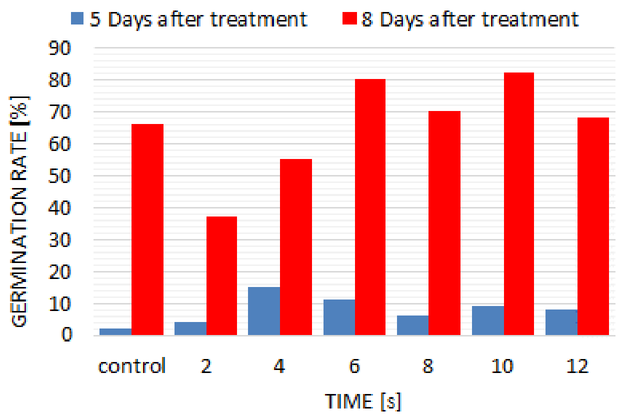

Fig.4. Dependence of rapeseed germination rate on the time of exposure to the electrostatic field for the voltage supplying the bifilar winding: a) 1 kV, b) 2 kV, c) 3 kV, d) 4 kV, e) 5 kV, f) 6 kV, g) 7 kV, h) 8 kV, i) 9 kV, j) 10 kV

Increasing the time of exposure of seeds to the electrostatic field does not cause a linear dependence on the germination rate. It can clearly be seen that there are two extremes at 4s and 10s, where the germination rate at 5 days is well above the control sample. Similar extremes can be observed for 8 days, with 6s and 10s, respectively. Both for 5 and 8 days, with the exposure time of seeds to the electrostatic field of 8s, the germination rate is much lower than for the control sample. The higher the voltage applied to the bifilar winding, the greater differences can be observed for the germination rate depending on the time of exposure of the seeds to the electrostatic field.

Conclusions

The conducted tests show that the electrostatic field generated by the bifilar winding affects the germination rate of rapeseed. The germination rate depends on the combination of rapeseed exposure time to the electrostatic field and field strength. These relationships are not linear. Similar observations are presented in [17,18].

In the conducted research, attention should be paid to the difficulty in estimating the plant growth phase. Differences in growth in some cases were minimal, which meant that on one occasion a given plant could be classified as ordinary, and in the next iteration as undeveloped. To minimise this error, the germination rate was determined by one person and the measurements were repeated three times and then the average value was determined.

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