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Influence of alternating low frequency magnetic field on improvement of seed quality

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A b s t r a c t. The paper shows the influence of magnetic field on improvement of seed quality. Spring wheat kernels were treated with a 16 Hz alternating magnetic field. Magnetic induction of the field was 5 mT. The optimum time of treatment of wheat seeds with alternating magnetic field equals 2 h. The best germination of seeds starts around 20 days after being treated with magnetic field. Presowing stimulation with alternating low-frequency magnetic fields has a positive influence on wheat grains germination.

K e y w o r d s: magnetic field, spring wheat, seed germination

INTRODUCTION

The main goal of agriculture is the production of appropriate foods quantities with a specific qualitative character. To achieve this goal, many things are needed for production. One method which improves a crop is fertilization. But this method is expensive and causes adverse effects on the environment. Therefore people strive to use those kinds of methods which are safe for the natural environment. Plants are exposed to physical stimuli, for example: infrared radiation, ultraviolet radiation, ionizing radiation, ultrasounds and magnetic fields (Bochniak and Wesołowska-Janczarek, 2005; Carbonell *et al*., 2000).

Despite many examinations, the effect of magnetic fields on plants is not still recognized. There are many hypotheses which explain the action of magnetic fields on organisms, but they are unable to explain all phenomena. The reason for this is selective treatment (Kornarzyński *et al*., 2004).

The aim of this study was to determine the possibility of applying an alternating magnetic field as a factor which has an impact on improving the quality of seed material, especially old and damaged seeds and to formulate optimum materials and methods for magnetic field application.

MATERIALS AND METHODS

The examination was carried out in the seed laboratory in the Department of Plant Physiology, Faculty of Agriculture and Biology, University of Agriculture, Warsaw. Seeds of spring wheat (*Triticum aestivum* L.) cv. Jasna were used in the investigation. This spring variety has high crop yield and good technological quality and has high resistance to diseases *eg* yellow rust, septoria glume blotch and stem rust. The examinations were based on two North Carolina II designs in three repetitions.

The first experiment began in December 2008. A factor which had an influence on the study material was the time of alternating magnetic field treatment with a frequency of 16 Hz. The first stage was checked for germination capacity of two-year-old, air-dry wheat seeds. Blotting paper with medium of speed seeping was used as a seed germination substrate. The moisture content of seed germination substrate equals 65% of full of water capacity of blotting paper. Germination was in the dark because seeds are indifferent to react to photoperiod. The examination was done in 3 repetitions, with 100 seeds each at optimum temperature.

In the second stage of experiments seeds were treated with an alternating magnetic field with the same parameters as the first experiment. The time of treatment was 2, 4, 8, 12 and 24 h in turn. Seeds were divided into 15 batches with 100 kernels each and placed in a generator. The magnetic field generator was constructed with two Helmholtz coils with opposing wind of wire in order to eliminate constituent part of the field. The magnetic field generator was constructed by the Technical University in Wrocław. The generator produces a homogenous magnetic field with a frequency of 16 Hz

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and a strictly determined magnetic flux density – 5 mT. This appliance was powered by an alternating field with a frequency of 50 Hz. After a specific time, the study samples were gradually taken out of this generator. The germination capacity marked 15 days from the end of seeds treated with an alternating magnetic field.

The first examination made it possible to determine the optimum time of seed treatment with a magnetic field. The second experiment was aimed at defining the time distance between treatments and examination of germination capacity, in order to use the maximum magnetic field effect. 5 dates of beginning germination were set: 1, 5, 12, 15 and 20 days after magnetic field treatment.

The control samples (seeds of spring wheat cv. Jasna) were not tested with the magnetic field.

The obtain results were statistically compiled by analysis of variance. The evaluation of LSD was done by Tukey test with a 5% margin of error.

RESULTS AND DISCUSSION

Figure 1 shows the correlation of germination capacities of wheat seeds from the time of seed treatment with an alternating magnetic field. As can be seen in Fig. 1, germination capacity decreased with prolongation of the time of treatment. Comparing the correlation between the time of seed treated with alternating magnetic field and their germination capacity (Table 1) we can find in 6 cases statistically significant differences (LSD) with $\alpha = 0.05$.

The highest germination capacity (about 17% compared to the control group of seeds) was found after magnetic field treatment during 2 h and the lowest (about 4%) after magnetic field treatment during 24 h. This means that irrespective of the time of the magnetic field seed treatment, it has a positive impact on the germination capacity of seed wheat.

However, with prolongation of the time of magnetic field seed treatment, this positive effect is lower. In comparison with control group these seeds germinate better even after 24 h of magnetic field treatment but the differences are not statistically significant.

The differences of germination capacity obtained after magnetic field treatment during 2 and 4 h are not statistically significant. The obtained results are respectively: 98 and 97%, so the result of the field effect is similar. Similarly, a correlation can be seen the time treatment for 2 and 8 h and 2 and 12 h was compared. A beneficial impact of the magnetic field on the germination capacity of seeds can be seen after treatment from 2 to 24 h. Therefore treatment of seeds with magnetic field for 2 or 4 h is better and more economic because during 24 h of magnetic field treatment a significant improvement of the studied effect can not be seen. The differences between the control group and the best treatment duration (2 and 4 h) are 17.3% and 16.7%. This means that an alternating magnetic field has a positive impact on the germination capacity of wheat seeds.

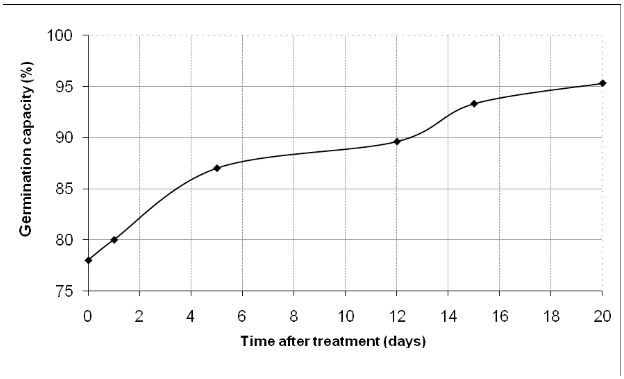

Fig. 1. The dependence of germination capacity of wheat seeds from time of seed treatment with alternating magnetic field.

T a b l e 1. The dependence between the time of seed treatment with alternating magnetic field and their germination capacity

Time treatment (h)	Differences (%)
0-2	-17.33*
0-4	-16.66*
0-8	-11.66*
0-12	-9.66*
0-24	-6.66
2-4	0.66
2-8	5.66
2-12	7.66
2-24	10.66*
4-8	5.00
4-12	7.00
4-24	10.00*
8-12	2.00
8-24	5.00
12-24	3.00

*Statistically significant differences in relation to the control group at $p>0.05$.

To sum up, the impact of magnetic field on the germination capacity of wheat seeds relies on improvement of germination capacity. The biggest effect of a magnetic field was obtained after 2 and 4 h of treatment. So there is not any practical justification for prolonging the time of treatment.

The Pieper coefficient (the average time of germination of single wheat seed) was calculated. The low value of this coefficient shows high vigour of seeds and fast seedlings.

T a b l e 2. Average time of germination (Pieper coefficient (days)) of a single wheat kernels after treatment with alternating magnetic field

Pieper coefficient	Time treatment of seeds with magnetic field (h)					
	0	2	4	8	12	24
Days	3.75	3.20	3.22	3.60	3.47	3.69

As can be seen in Table 2, the speed of germination of a single wheat seed cv. Jasna exposed to magnetic field is lower than the control group so the obtained result is beneficial. The low value of Pieper coefficient shows high vigour of seeds. So the longer seeds stayed under the influence of the magnetic field then, in common with laboratory germination capacity, the effect decreased.

Seed material was again exposed to alternating magnetic field treatment with optimal values for stimulation results. The examination of germination capacity carried out at various times of treatment (1 to 20 days).

Data in Fig. 2 showed that the longer the time from being treated with alternating magnetic field to examination of germination capacity, the effect of the magnetic field increases. The highest effect was obtained 20 days after magnetic field treatment (germination capacity 95.3%).

Comparing germination capacity after treatment (95.3%) with control (78%) one can notice an improvement of about 17.3%.

Comparing the correlation of the effect of seed treated with alternating magnetic field and the time length between seed treatment and examination of germination capacity can be found statistically significant differences in 7 cases (LSD) with α = 0.05 (Table 3). The highest value of germination capacity (97%) compared with the control was found 20 days after treatment with magnetic field. But the lowest value (78%) was noted 1 day after treatment. LSDs were observed comparing a day with three dates of germination beginning 12, 15 and 20 days. Data in Table 3 showed that markedly better is delayed germination for obtaining a better result. There is not a statistically significant difference of germination capacity after 1 day from treatment. A similar effect was observed comparing the first day with the second examination (5 days). The beneficial effect of field increased along with the length of time which elapsed from treatment to examination of germination capacity of wheat seeds.

Table 4 showed the average time of seedlings of wheat seeds depending on the time between treatment and moment of germination beginning. When the time of germination beginning was extended then the Pieper coefficient decreased, which pointed to the increasing vigour of the examined seeds.

On the basis of experimental data and Statgraphics program the optimal method of treatment with alternating magnetic field was compiled. The alternating magnetic field with a frequency of 16 Hz and a strictly determined magnetic

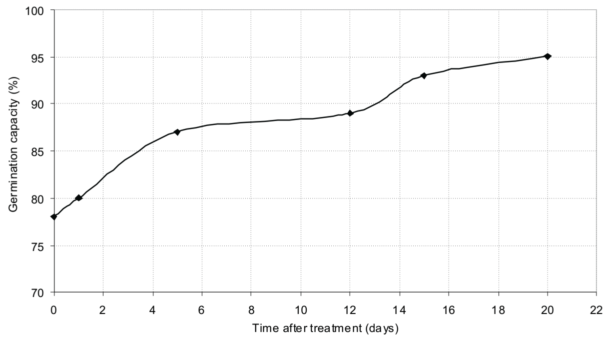

Fig. 2. The dependence of germination capacity of spring wheat seeds *cv*. Jasna from time between treatment and beginning of examination of germination capacity.

T a b l e 3. Measure of the significance of the effect of the field to the length of time between the treatment and examination of seed germination capacity

Days from treatment with magnetic field	Differences (%)
0-1	- 2.33
0-5	- 9.06*
0-12	-11.66*
0-15	-15.33*
0-20	-17.33*
1-5	-6.66
1-12	-9.33*
1-15	-13.00*
1-20	-15.00*
5-12	- 2.66
5-15	- 6.33
5-20	- 8.33
12-15	-3.66
12-20	-5.66
15-20	-2.00

*Explanations as in Table 1.

T a b l e 4. The average time of germination (Pieper coefficient (days)) of spring wheat kernels cv. Jasna depending on the time between treatment and moment of germination beginning

Pieper coefficient	Time treatment of seeds with magnetic field (h)					
	0	1	5	12	15	20
Days	3.75	3.73	3.67	3.68	3.16	3.38

flux density – 5 mT has a positive impact on the germination capacity of seeds of spring wheat (*Triticum aestivum* L.) *cv*. Jasna. The results of examinations suggest that the maximum, positive effect of magnetic field (time of treatment) was obtained with a shorter period of the magnetic field effect. The obtained results show that the longer the seeds were treated with alternating magnetic field, the less effective the result was.

The second factor which has a positive impact on improving wheat seed quality is the time between treatment and examination of their germination capacity. The most beneficial result was obtained 20 days after field stimulation.

The impact of current and alternating magnetic field on the seed quality of different species of agricultural plants has been the subject of numerous experiments. Most often the results and descriptions of this kind of experiments can be found among publications from the end of XX and beginning of XXI centuries (Balouchi and Modarres Sanav, 2009; Carbonell *et al*., 2000; Pietruszewski, 2002; Raciuciu *et al*., 2008a; Rochalska, 2007).

In a corporate article edited by Kornarzyński (2004) one can find a description of experiments which strive to describe the impact of current magnetic field on the sequence of profiles of the speed of seeds increasing and wheat seedlings. The most negative impact of magnetic field was observed (Kornarzyński *et al*., 2004) for low (5 and 15 mT) and high (100 and 130 mT) magnetic flux density but in average cases (30 and 60 mT) – the weakest; however after a period of around 120-130 h, the process became almost the same for different flux density values. The results which are described in this article show the positive impact of alternating magnetic field on the corresponding seed trials, except for the application of flux density of around 0.05 mT (Kornarzyński, 2004).

Pietruszewski (2002), in examining the impact of magnetic field on the seeds of different species of agricultural plants, describes, among other things: the strong impact of the current magnetic field on the wheat seeds. According this publication a current magnetic field has a more positive impact on wheat germination than an alternating magnetic field, maintaining a higher value of flux density (100 and 185 mT for current, with 35 and 50 mT for alternating field) for the first. The magnetic field has a different impact on the individual plants. The best effect was obtained in cabbage seeds when current magnetic field was used (with value of flux density appropriately 70, 120, and 210 mT) (Pietruszewski, 2002).

The results obtained by different authors confirm the beneficial influence of current magnetic fields on the quality of seed material of agricultural plants, especially wheat seeds (Fischer *et al*., 2004; Pietruszewski, 2001; Pietruszewski and Kania, 2010; Rochalska and Orzeszko-Rywka, 2005; Rochalska *et al*., 2009). Examinations into magnetic field were also made for plants other than agricultural plants (Dominguez *et al*., 2010, DeSouza *et al*., 2009, Turgay *et al.,* 2010, Zepeda *et al*., 2010). For example the impact of alternating magnetic field was made for seedlings of pink feathery and lupine seeds in the middle of germination (Kornarzyński and Łacek, 2006). The positive impact of magnetic field was improved but only in the initial term of germination. However, authors showed that in the case of most plants a magnetic field has a negative impact on the germination capacity of seeds (Kornarzyński and Łacek, 2006). Based on the above examinations it can be deduced that magnetic fields – current or alternating – have a positive impact not only on cereals but also on different agricultural and ornamental plants. But this positive effect appears only in the case of application of magnetic field in the initial phase of germination (Kornarzyński and Łacek, 2006).

Until now the results of the current examinations confirm the possibility of using magnetic field for presowing improvement of the quality of cereals seed material (Raciuciu *et al*., 2008b; Sasao *et al*., 1998; Tugulea *et al*., 2000). Determining the optimum methods of applying this factor can contribute to its optimum use. Alternating magnetic field with a frequency of 16 Hz and a strictly determined magnetic flux density – 5 mT has a positive impact on wheat seeds. The time of treatment of wheat seeds should be equal to at least 2 h and the time distance between treatment and sowing – 20 or more days.

CONCLUSIONS

1. The presowing treatment of wheat seeds with alternating magnetic field using a low frequency increases their germination capacity.

2. The optimum time of treatment of wheat seeds with alternating magnetic field with a frequency of 16 Hz and a magnetic flux density – 5 mT equals 2 h.

3. The best germination of seeds starts around 20 days after being treated with magnetic field, and then the germination capacity of wheat is the largest.

4. When the beginning of germination of wheat seeds is delayed then their germination capacity increases. An upward trend is maintained up to 20 days after ending treatment with magnetic field. It can be inferred then that stabilization will occur and then a slow drop after around 25-30 days.

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