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EFFECT OF THE STATIONARY MAGNETIC FIELD ON THE GERMINATION OF WHEAT GRAIN

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A b s t r a c t. The effect of strong stationary magnetic field on absorbing capacity of water and respiration intensity of germination seeds, for the first germination phases and growth, were observed. The main goal of this study was to define influence of the stationary magnetic field of 50 mT to 1.0 T on the germination speed at different moisture contents of wheat grain. For investigations Henika variety of wheat grain was used. The moisture content of grain was increased by puting grains on the moist paper on Petri dishes for a definite period of time. The results obtained to state that a strong magnetic field had more positive effects on wheat grain germination.

K e y w o r d s: magnetic biostimulation, strong stationary magnetic field, germination speed of wheat seeds

INTRODUCTION

Influence of magnetic field on plant germination, growth and yield is part of biomagnetism. A pre-sowing magnetic biostimulation of plant seeds depends on the effect of stationary or alternating magnetic field on the seeds before sowing [1,2]. Influence of magnetic field on different processes in biological objects, such as seeds, is one of the physical pre - sowing seed treatments. On the basis of purely theoretical calculations on the molecular - magnetic - field interaction, scientists mantained that mechanism of biomagnetic effects is connected with physical phenomena occurring on the molecular and atomic levels, for example dia- and paramagnetic molecular orientation exchange in the magnetic field.

Majority of biological materials, particularly plant seeds, are diamamagnetic substances [6]. The effect of external magnetic field on the diamagnetic moments is proportional to the density of external magnetic field energy and exposure time. This value is defined as a magnetic exposure dose [3,5].

The germination of sowing material is defined on the basis of two measurements with obligatory international standard. The first count of germination capacity was made four days after sowing (for wheat seeds) and second count of germination capacity was made eight days after sowing. A good sowing material should have germination capacity of about 90-95%. Two measurements made every fourth day do not inform us, how the process develops in time. It refers to good sowing materials which have moisture content resulting from storage. Investigation carried out at the Department of Physics, University of Agriculture in Lublin focused on the determination of germination speed of wheat grain during the first few days after magnetic biostimulation and the influence of moisture content on this process.

MATERIAL AND METHOD

The influence of stationary magnetic field on the germination capacity and germination speed of wheat seeds (Henika cultivar) was the object of this investigation. For the purpose of this study an appropriate electromagnet was made by the present authors. The electromagnet was assembled from magnetic cores made from eight independent Armco iron field coils. Within the air gap a smooth adjustment of the magnetic field from 0 to 1.2 T could be obtained. Since the seeds were put in the central place of the magnetic field, it was possible to assume that the magnetic field in this case was homogeneous.

All the quoted magnetic inductions were measured with a gaussmeter TH 26 manufactured by the Experimental Institute of Biocybernetics, Polish Academy of Sciences. The gaussmeter had a probe with a Hall generator model EA 218 by Siemens. The accuracy of measurement of magnetic induction with gaussmeter TH 26 was 1.5%.

The gaussmeter measured the magnetic induction on the basis of Hall voltage observed in the probe. In this case (the stationary magnetic field) the magnetic exposure dose D was defined as:

$$D = \frac{10^7}{8\pi} B^2 t \qquad (\mathrm{J\,m^{-3}s})$$

where: B - value of magnetic induction (T) measured with the gaussmeter, t - exposure time (s).

The investigations made at the Department of Physics were to define germination speed of wheat seeds after magnetic biostimulation. The research was carried out for three exposure doses: $D_1 = 99.47\ 10^3\ \mathrm{J\,m^{-3}\,s}$ (50 mT; t = 100 s), $D_2 = 6.366\ 10^6\ \mathrm{J\,m^{-3}\,s}$ (0.4 T; t = 100 s) and $D_3 = 39.788\ 10^6\ \mathrm{J\,m^{-3}\,s}$ (1 T; t = 100 s).

The seeds of spring wheat Henika cultivar was the object of germination tests. A number of 100 seeds in eight replications were put in the magnetc field with magnetic induction of 50 mT, 0.4 T and 1 T in 100 s time. Then the seeds with the control were put away for germination on the Petri dishes. All the grains were put furrow down on the humid blotting-papper. The first and second counts of the germination capacity were carried out according to the Polish Standards PN-79/R-65 950 "Investigation methods of seeds" [4].

In this investigations six moisture contents of seeds were employed: $W_1 = 10.2\%$, $W_2 = 20.2\%$, $W_3 = 24.3\%$, $W_4 = 28.4\%$, $W_5 = 32.1\%$ and $W_6 = 34.2\%$. The seeds of higher moisture content were obtained by puting them on the humid blotting-papper on the Petri dishes for: 0, 2, 4, 8 and 12 h. The moisture content of seeds was taken according to the Polish Standards at the temperature of 130 C in 60 min periods.

The speed of germination of wheat seeds was defined as the increment of the number of germinating seeds between the measurements. The results are presented as the relation between germination capacity and germination time.

RESULTS

On the basis of the obtained results it may by confirmed that germination capacity of wheat seeds depended on the magnetic exposure dose employed and moisture content of wheat grains (Table 1). An increase of germination capacity may be observed with greater doses (strong magnetic field, B = 1T) and low moisture content of wheat seeds (Fig. 1). An increase in the moisture content of wheat grains decreased germination capacity and speed of germination and for the most moist seeds was lower than control (Fig. 1).

Higher moisture contents of seeds resulted in higher germination capacity. On the basis of the above it was confirmed that the seeds need less time to reach corret moisture to make germination possible.

It may be confirmed that the speed of germination is greater for the seeds with low moisture content and strong magnetic field. The speed of germination for the seeds with moisture content W=10.2% reached the maximum after about 38 h and magnetic field with 1 T magnetic induction, for magnetic field 0.4T magnetic induction after about 41 h and for the control after about 44 h (Fig. 2). The seeds subjected to the influence of a very strong magnetic field reached maximum of germination speed about 6 h earlier than the control. The speed of germination of wheat grains

Table 1. Germination of wheat grain

Time (h)	Control	B = 50 mT	B = 0.4 T	B = 1 T	Time (h)	Control	B = 50 mT	B = 0.4 T	B = 1 T
		W = 10.2%					W = 20.2%		
34.5	6.0 ± 1.67	7.2 ± 1.72	8.2 ± 1.67	8.4 ± 1.85	29.0	9.2 ± 2.97	3.2 ± 1.6	4.6 ± 1.36	10.0 ± 2.04
38.5	47.8 ± 2.14	48.8 ± 7.17	51.6 ± 7.2	67.6 ± 5.34	34.4	42.6 ± 4.17	39.0 ± 5.53	36.0 ± 3.26	42.8 ± 4.32
44.0	79.6 ± 2.71	80.0 ± 3.18	79.8 ± 4.17	85.2 ± 3.49	40.5	76.2 ± 2.27	75.2 ± 1.32	69.8 ± 8.61	79.2± 3.26
48.5	88.0 ± 1.86	87.5 ± 3.35	87.8 ± 3.74	89.6 ± 2.25	48.5	88.7 ± 3.18	85.4 ± 2.42	82.6 ± 4.57	89.8 ± 3.14
62.5	91.2 ± 2.14	91.2 ± 2.04	92.6 ± 1.47	92.6 ± 0.63	53.5	94.3 ± 2.73	91.0 ± 1.36	88.8 ± 1.94	95.6 ± 2.04
68.5	95.0 ± 1.17	95.4 ± 1.83	94.2 ± 1.6	95.8 ± 0.75	58.5	96.9 ± 1.62	94.2 ± 1.94	93.0 ± 2.03	96.8 ± 0.75
		W = 24.3%					W = 28.4%		
28.5	20.6 ± 1.96	21.8 ± 4.75	23.6 ± 5.38	29.0 ± 4.19	22.5	8.2 ± 3.18	5.6 ± 1.85	9.4 ± 1.85	11.0 ± 2.19
32.5	42.6 ± 6.01	43.2 ± 3.78	44.8 ± 2.64	53.6 ± 2.73	26.5	34.4 ± 5.49	29.2 ± 2.73	36.6 ± 4.31	42.8 ± 3.37
46.5	73.6 ± 4.83	73.0 ± 8.63	70.4 ± 3.93	77.0 ± 10.07	30.5	68.2 ± 4.17	66.2 ± 2.0	74.4 ± 2.56	77.4 ± 6.02
53.0	81.2 ± 2.06	80.8 ± 1.94	78.4 ± 2.75	82.8 ± 1.32	39.5	87.6 ± 5.27	87.8 ± 3.83	88.6 ± 3.87	90.4 ± 4.69
58.5	86.6 ± 1.74	87.8 ± 1.89	84.4 ± 3.16	88.2 ± 1.63	43.5	91.0 ± 2.73	93.2 ± 1.36	91.8 ± 0.75	93.4 ± 1.09
63.5	90.8 ± 1.02	90.0 ± 1.47	89.8 ± 1.41	92.2 ± 1.26	53.5	98.2 ± 1.32	96.0 ± 1.6	95.8 ± 2.6	97.2 ± 0.75
70.5	93.1 ± 1.49	94.2 ± 0.75	93.8 ± 1.02	95.3 ± 1.46					
		W = 32.1%					W = 34.2%		
16.5	5.25 ± 1.92	2.2 ± 2.48	4.0 ± 0.89	6.0 ± 2.89	17.5	8.8 ± 1.72	7.8 ± 1.83	7.0 ± 0.89	7.6 ± 0.8
23.5	20.8 ± 1.5	16.4 ± 7.22	17.0 ± 2.76	21.2 ± 5.15	21.5	42.6 ± 5.23	35.4 ± 3.56	29.6 ± 2.42	31.4 ± 3.12
35.5	59.8 ± 3.39	61.6 ± 2.48	51.6 ± 3.07	57.0 ± 4.71	25.5	70.0 ± 4.22	58.2 ± 1.33	54.6 ± 4.77	62.6 ± 5.34
41.0	78.3 ± 2.18	78.8 ± 6.14	69.0 ± 1.62	69.8 ± 3.65	30.0	87.0 ± 4.0	75.4 ± 7.08	70. 4 ± 4.53	79.2 ± 1.96
47.5	84.8 ± 3.2	85.8 ± 1.67	75.8 ± 1.47	76.6 ± 0.98	34.5	92.4 ± 1.36	83.2 ± 2.48	79.4 ± 2.87	84.4 ± 1.33
64.5	92.3 ± 3.2	91.0 ± 2.78	85.0 ± 2.93	86.6 ± 2.97	43.5	95.4 ± 0.63	92.8 ± 1.85	93.0 ± 2.94	96.8 ± 2.58
67.5	93.8 ± 1.12	91.6 ± 0.8	91.0 ± 3.03	90.6 ± 1.55					

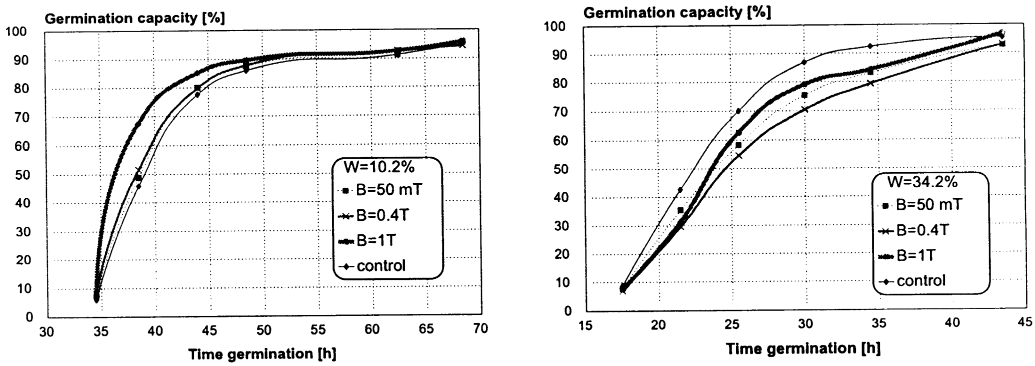

Fig. 1. Relationship between germination capacity of wheat seeds and germination time for seed moisture content 10.2 and 34.2%.

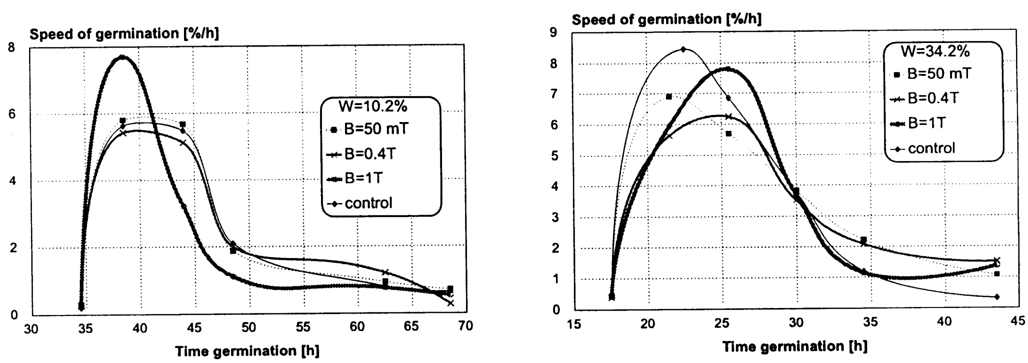

Fig. 2. Speed of germination for the different magnetic inductions, 100 s exposure time and seed moisture content 10.2 and 34.2%.

subjected to the influence of weak magnetic field ($B = 50$ mT) and the control was the same.

Speed of germination of wheat seeds with W = 34.2% moisture content subjected to the influence of magnetic field with B=1 T magnetic induction reached maximum about 5 h later than the control (Fig. 2).

The relation between the seeds germinating 35 h after biostimulation and their moisture content is shown in Fig. 3. The graphs show that the border moisture content after crossing negative influence of magnetic field on germination is about 29-30%. It is the highest for the strong magnetic field. The relationship between germination capacity of wheat seeds and germination time for different seed moisture contents and 1 T magnetic induction, are shown in Fig. 4. The graphs show that germination capacity depends on the moisture content of seeds. The seeds with 10.2% moisture content germinated earlier than the seeds with 34.2% moisture content.

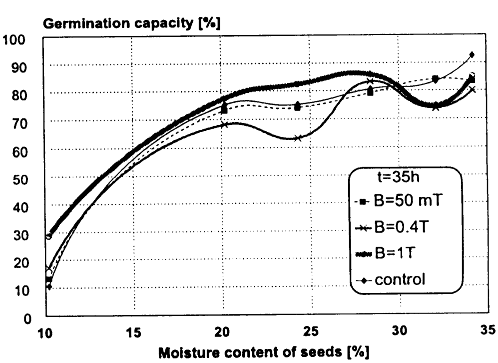

Fig. 3. Relationship between germination capacity after 35 h after sowing and moisture content of wheat seeds for different magnetic inductions.

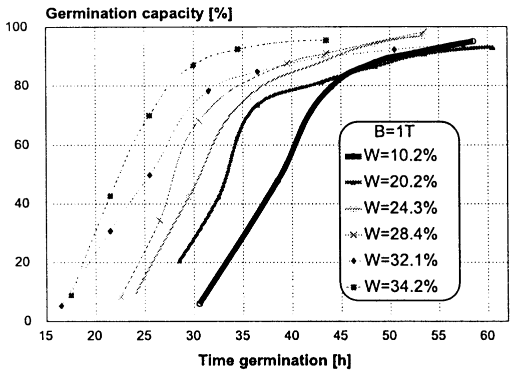

Fig. 4. Relationship between germination capacity of wheat seeds and germination time for different moisture content of seeds.

CONCLUSIONS

The presented investigations determined that the speed of germination of wheat seeds depends on the magnetic induction and moisture content of seeds.

1. Strong magnetic field caused better germination of seeds with low moisture content.

2. An increase of moisture content decreased the influence of magnetic field.

3. Maximum speed germination depends on the moisture content of seeds and the strenght of magnetic field.

On the basis of the obtained results it may be confirmed that the stationary magnetic field can be used for biostimulation of wheat seeds. Stationary, strong magnetic field and low moisture content of seeds have increased the speed of germination by about 12-15% and quickened the occurance of maximum germination speed by 6 h.

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