THE THRESHOLD VALUE OF THE STATIC MAGNETIC FIELD INDUCTION FOR GTAVITROPIC REACTION DEPENDS ESSENTIALLY ON THE RELATIVE DIRECTION OF STATIC MAGNETIC FIELD AND ROOTS OF PLANTS

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Abstract. It was studied by us earlier the effect of static vertical magnetic field on the gravitropic reaction of cress roots while the horizontal magnetic field was absent. It was revealed here that the dependence of gravitropic reaction on the magnitude of magnetic induction of static magnetic field has the threshold. The value of the threshold magnetic induction was determined. This work is devoted to the investigation of the action of horizontal magnetic field on the gravitropic reaction of cress roots while the vertical magnetic field component is shielded. It was revealed that the gravitropic reaction of cress roots depended essentially on the relative location of roots and static magnetic field. Although in all cases the gravitropic reaction had the threshold character, the magnitude of the threshold essentially differed (by two orders) for different directions of roots relatively the static magnetic field. Two explanations of the effects observed were proposed. The first one was based on the quantitative difference between the interactions of static magnetic field with ions and ions magnetic moments. It was shown that both effects were possible. The difference was caused by ions downstream. It was shown that only during interaction of static magnetic field with ions the anisotropy of the threshold value was possible. The only objection for the model was the fact that fee path of ions was too little. The other possible explanation was based on the phase transition in water in the vicinity of the membrane and formation of domains. . In that case in the first model we accounted that the ion might rotate in static magnetic field in vacuum zone next to water domain. And the free path of ion increased essentially. This fact neutralized all objections.
Key words: *static magnetic field, roots' gravitropic reaction, the action threshold, relative orientation of roots and magnetic field, phase transitions in water, domains.*

INTRODUCTION

It was revealed before, that effect of combined magnetic field depended essentially on the roots' direction relatively combined magnetic field direction [1-3] This work is devoted to studying of influence of horizontal static magnetic field on the cress roots gravitropic reaction while the vertical component of magnetic field was shielded. The effect of vertical static magnetic field on the gravitropic reaction of cress roots while the horizontal component of static magnetic field was shielded was studied in [4]. The threshold for vertical magnetic field action was determined in [4].

MATERIALS AND METHODS

The scheme of the set we used is showed on figure 1 [1, 2].

The μ-metal shield with bottom 2 was located on the rubber 1 damping the vibrations of the building. The rings 3 from non-magnetic material centered the solenoid's coils 4 and 5 relatively the central axis of the shield. The coil 5 was used for creating of static magnetic field in solenoid, while the coil 4 was used for creating of alternative magnetic field in solenoid. 6 was the stand from nonmagnetic material, on which the moist chamber 9 with the cress roots was located.

The roots 8 (two days germinated seeds) were located on the stand 7 in the chamber 9. The roots might be located both parallel shield's axis and perpendicular to it. The temperature in the chamber was stabilized with the precision 0.2^o. The external appearance was showed on figures 2, 3 [1, 2].

To observe the biological effects caused by static magnetic field it was necessary to provide the homogeneity of magnetic field not less than 1.5%. Such a homogeneity in the construction we used was provided in the cylinder of the diameter 60-70 mm around the cylinder axis and 8-12 mm along it. So the roots length couldn't exceed 8 -10 mm for roots located along the axis of the shield.

As we usually used the roots with the length 15-20 mm it was necessary to use some added windings at the ends of solenoid to increase the region of magnetic field's homogeneity.

SCHEME OF EXPRIMENT

The magnetic noises of μ-metal shield located in horizontal plane were measured by means of flux-gate magnetometer and spectra analyzer at the frequency region from 10^{-4} until 100 Hz and by means of induction coil and narrow region amplifier U2-6 at the frequency region 16 Hz – 100 kHz. The coefficient of decreasing of magnetic field was measured too/.On the basis of results obtained the electric field noises were counted.

The results obtained were showed on figures 4 and 5.

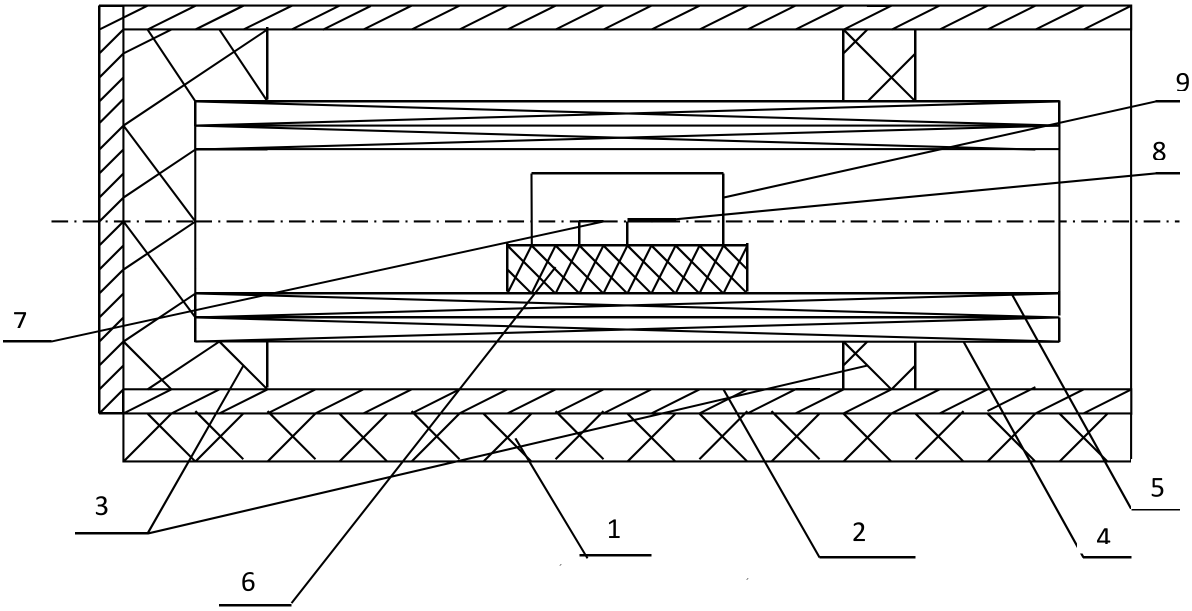

Figure 1. The sight of experimental set in section: 1 – damping rubber; 2 – two layers μ-metal shield with a bottom; 3 – rings made from non-magnetic material, that centralize the solenoids' coils 4 and 5 relatively the central axis of the shield; 4 and 5 – the coils of solenoids; 6 – the stand of non-magnetic material; 7 – the stand of non-magnetic material inside the moist chamber; 8 – roots of cress; 9 – the moist chamber

Figure 2. The external sight of the set from the side

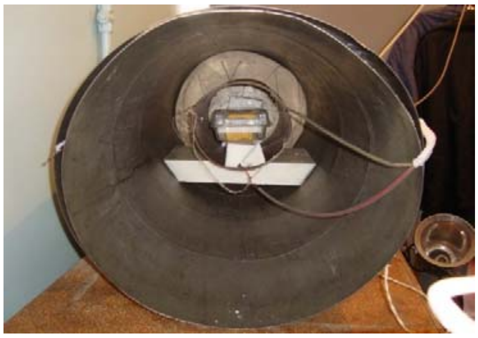

Figure 3. The external sight of the internal part

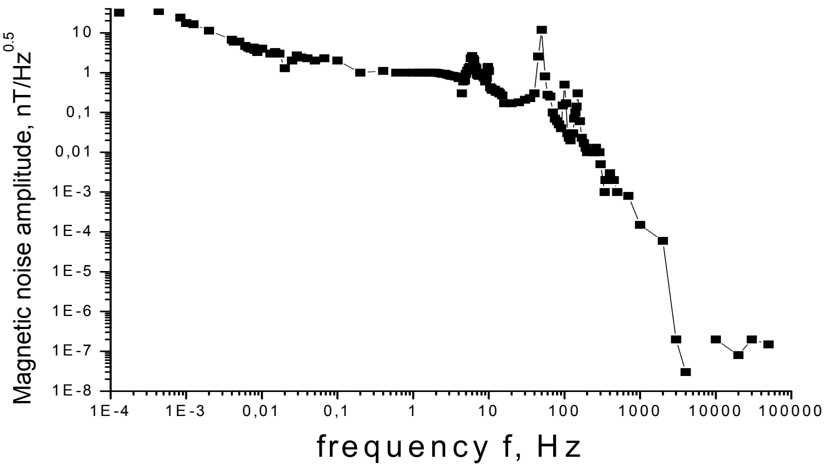

Figure 4. The dependence of amplitude of spectral density of magnetic noise for the system: μ-metal shield + flux gate magnetometer (10^{-4}-100Hz) or μ-metal shield + induction method (16 Hz-100 kHz). Results of different measurements in the region 16-100Hz coincides between themselves very well

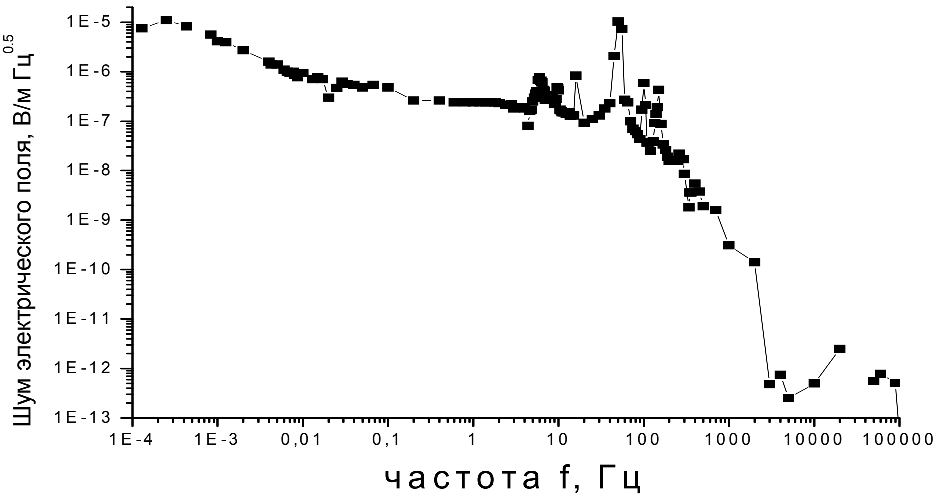

Figure 5. The dependence of amplitude of spectral density of electric field noise for the system: μ-metal shield + flux gate magnetometer

As we can see from the figures there are 3 peaks in the region of frequencies 5-10 Hz (near 5 Hz, 8 Hz, and 9.5 Hz) and 3 well visible peaks at 50, 100 and 150 Hz.

The measurement of spectral noise density was fulfilled by the same way. At first the drift of magnetic field in the shield was measured during the day by means of flux gate magnetometer, connected with the Furies spectra analyzer. The measurements gave us the noise curve at the frequencies from 10^{-4} until 100Hz. Then by means of induction coil and narrow region amplifier U2-6 we measured the signal at the frequencies from 16 Hz until 100 kHz and the obtained results were divided by the coefficient of shielding of the shield.

Coefficient of shielding was determined by the following way. The shield was located in the big solenoid, in which the rather big magnetic field had been created. The magnetic field was measured without the shield and then inside the shield located in the solenoid. The relation of the external magnetic field to the magnetic field that penetrated inside the shield was the coefficient of shielding. We had to notice here that the magnitude of magnetic noise obtained by these two different methods in the frequency region 16 -100 Hz coincided between themselves very well.

The roots with the length 10-20 mm were located on the stand of nonmagnetic material so that they were parallel to the earth's surface, so perpendicular to the gravity. There were two variants of experiments. In the first one the roots were located parallel to the static magnetic field, in the second one they were located perpendicular to lt. The control samples were located both in the «zero'' magnetic field and in the magnetic field that was equal to the magnetic field of the Earth.

RESULTS AND DISCUSSIONS

The results obtained were showed on the figures 6 and 7 for roots direction parallel to magnetic field and perpendicular to gravity vector. Figures 8 and 9 corresponded to the case when the roots direction was perpendicular both to magnetic field and gravity vector.

It was clear from the figures that in the case when the roots were parallel to the horizontal vector of magnetic field the threshold transition was rather steep. It began at 10 μT and ended approximately at 30 μT (fig. 6). In the case when the roots were directed perpendicular to the magnetic induction vector the transition was prolonged and seemed to consist from two transitions. The first one began at 4 μT and ended at 8 μT, the second one began at 10 μT and ended approximately at 30 μT (fig.8). The threshold in vertical magnetic field was located at the values of magnetic induction by two orders lower. It began at the magnetic induction value 0.1μT and finished at 1μT [4]. Such essential difference for the threshold value of magnetic induction might explain very old results of Yu. I. Novitskiy and M.P. Travkin [5], that was different development of roots systems for different initial orientation of roots north-south or west-east. We could conclude from these results that the main flux of ions that were important for gravitropic reaction was directed along the roots. It was possible that it was the flux of magnetic ions. At first the difference of the threshold values of magnetic field between the ions and magnetic moments was discussed by us in [6]. It was shown there at first the analogies in the magnetic and gravitation fields actions too.

We have to notice here that the kinetic energy of rotating ions was essentially more than the energy of magnetic moments in magnetic field. It was caused by the fact that the ion was rotating along the membrane (the radius of the cell was approximately 5 μ) and the radius of the molecule was lower. The simple estimations gave the following results.

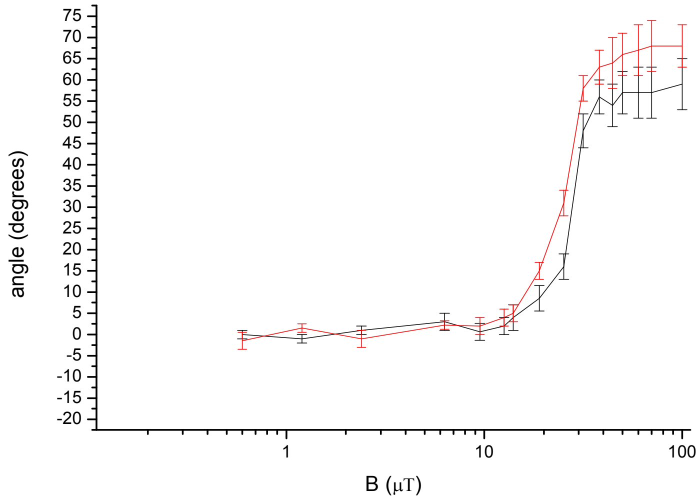

Figure 6. Dependence of the angle of roots divergence from the horizontal plane on the magnitude of static magnetic field. Curve A (black) was for 1 hour treatment in experimental static magnetic field, curve B (red) was for 1.5 hour treatment. The roots were parallel to magnetic induction vector

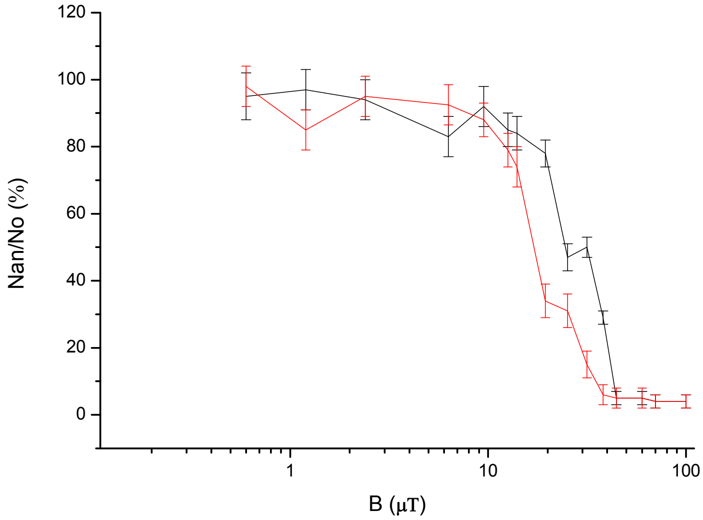

Figure 7. The dependence of % of anomalous roots on the magnitude of static horizontal magnetic field. Curve A (black) was for 1-hour treatment in experimental static magnetic field, curve B (red) was for 1.5-hour treatment. The roots were parallel to magnetic induction vector. The roots were counted anomalous if they didn't diverge from the horizontal plane or if they diverged up

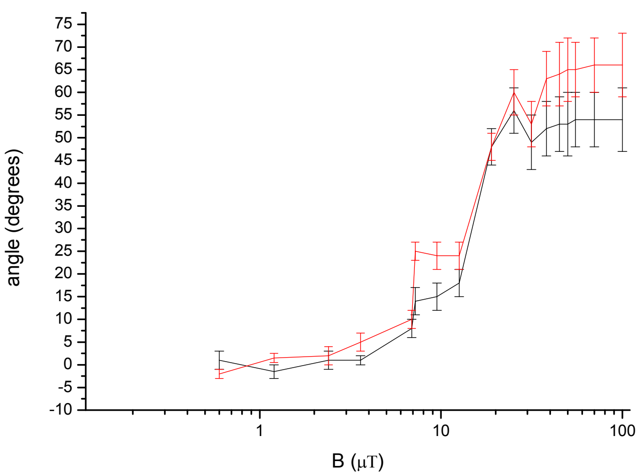

Figure 8. Dependence of the angle of roots divergence from the horizontal plane on the magnitude of static magnetic field. Curve A (black) was for 1-hour treatment in experimental static magnetic field, curve B (red) was for 1.5-hour treatment. The roots were perpendicular to magnetic induction vector

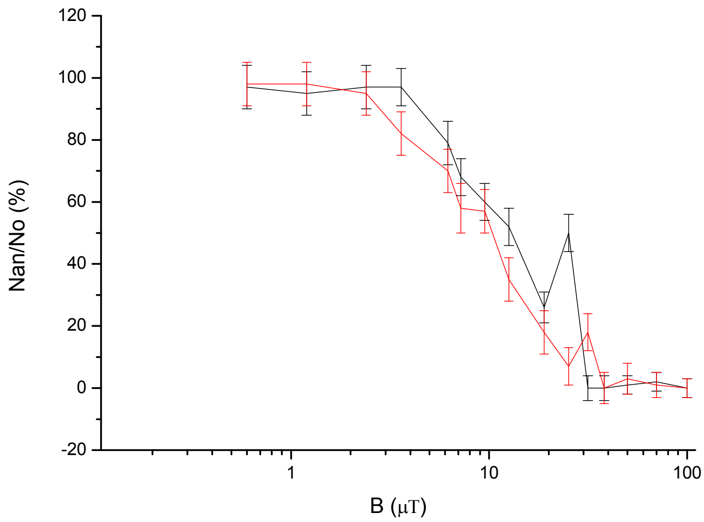

Figure 9. The dependence of % of anomalous roots on the magnitude of static horizontal magnetic field. Curve A (black) was for 1-hour treatment in experimental static magnetic field, curve B (red) was for 1.5-hour treatment. The roots were perpendicular to magnetic induction vector. The roots were counted anomalous if they didn't diverge from the horizontal plane or if they diverged up

The threshold of gravity action on roots was at the level (10^{-4}- 10^{-3}) g. The energy of rotating ion in the magnetic field seemed have the same value. [6], the potential energy of ion in gravity was equal

$$U = m \cdot (10^{-4} - 10^{-3}) \cdot g \cdot a. \tag{1}$$

Here *m* was mass of ion, for instance for calcium ion, a was the dimension of plant cell that was approximately 10 μ., *g* was the acceleration of free fall on the Earth. The submitting of quantities in (1) gave the value U= (10^{-32}- 10^{-33})V.

The energy of magnetic moment in the magnetic field with the magnetic induction B was equal

$$U = m \cdot B. \tag{2}$$

Here M was magnetic moment for calcium ion, it was of the order 10^{-28}J m^2/Vibe. So for the threshold B we obtained the value 10 – 100 μT.

Analogically the energy of the rotating ion in the magnetic field was counted. It was equal

$$U = m\omega^2 a^2/2. \tag{3}$$

And taking in account that

$$\omega = qB/m. \tag{4}$$

Here *q* was the ion charge; *ω* was its cyclotron frequency in the magnetic field. So for the threshold B we obtained the value 0.1-1 μ T.

So it was shown that in gravitropic reaction in the magnetic field took part both ions and magnetic moments of these ions. While the moving of ions had the determined direction the difference in the threshold values of magnetic induction for different roots direction might be very big until 2 orders. The effect was observed in this work. Besides for some directions of magnetic field a few thresholds could be observed. We saw the effect in vertical magnetic field [4] and in this work. It was necessary to take into account that in the gravitropic reaction could take part different ions with different magnetic moments. That might to cause the complicated form of the threshold curve.

The other explanation of the presence of the threshold in the action of static magnetic field is based on the new works about the phase transition in the water [10-15].In static magnetic field the ions may rotate around the water domains in the vacuum region between domains, that is of the order 10 nm and they don't leave the region. So they don't take a part in the chemical processes. That leads to the changes in gravitropic reaction. The process begins from the field that corresponds the most little radius of cluster and finishes at the most big one. The domains can have non spherical form and their smallest and biggest radiuses in different directions may differ. We have to notice here that in our experiment even remained magnetic field at the frequency 50 Hz in the 3layed μ-metal shield (at the level 20-50 nT) is enough to generate phase transitions in water. In our experiments only in superconducting shield it may be decreased by 1000 times. But in superconducting shield we cannot create horizontal magnetic field because of lack of dimensions in horizontal direction.

CONCLUSIONS

1. The different threshold values of magnetic induction for gravitropic reaction creation was observed experimentally for different relative direction of roots, horizontal vector of magnetic induction and gravity vector.

2. The effects observed were compared with the results obtained for vertical magnetic field threshold value.

3. Two explanations of difference between the threshold values of magnetic induction in different directions was proposed. The first one was connected with the determined direction of ion's flux in the vertical magnetic field and action on ions. In the horizontal magnetic field the threshold value was determined by the action on the magnetic ions. The second one was connected with the phase transition in whater

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