MAIZE AND CRESS ROOTS ORIENTATION IN COMBINED MAGNETIC FIELD CHANGE GRAVITROPIC REACTION RESPONSE ON CMF. EXPERIMENT AND NEW HYPHOTESIS. ADAPTATION MECHANISM.

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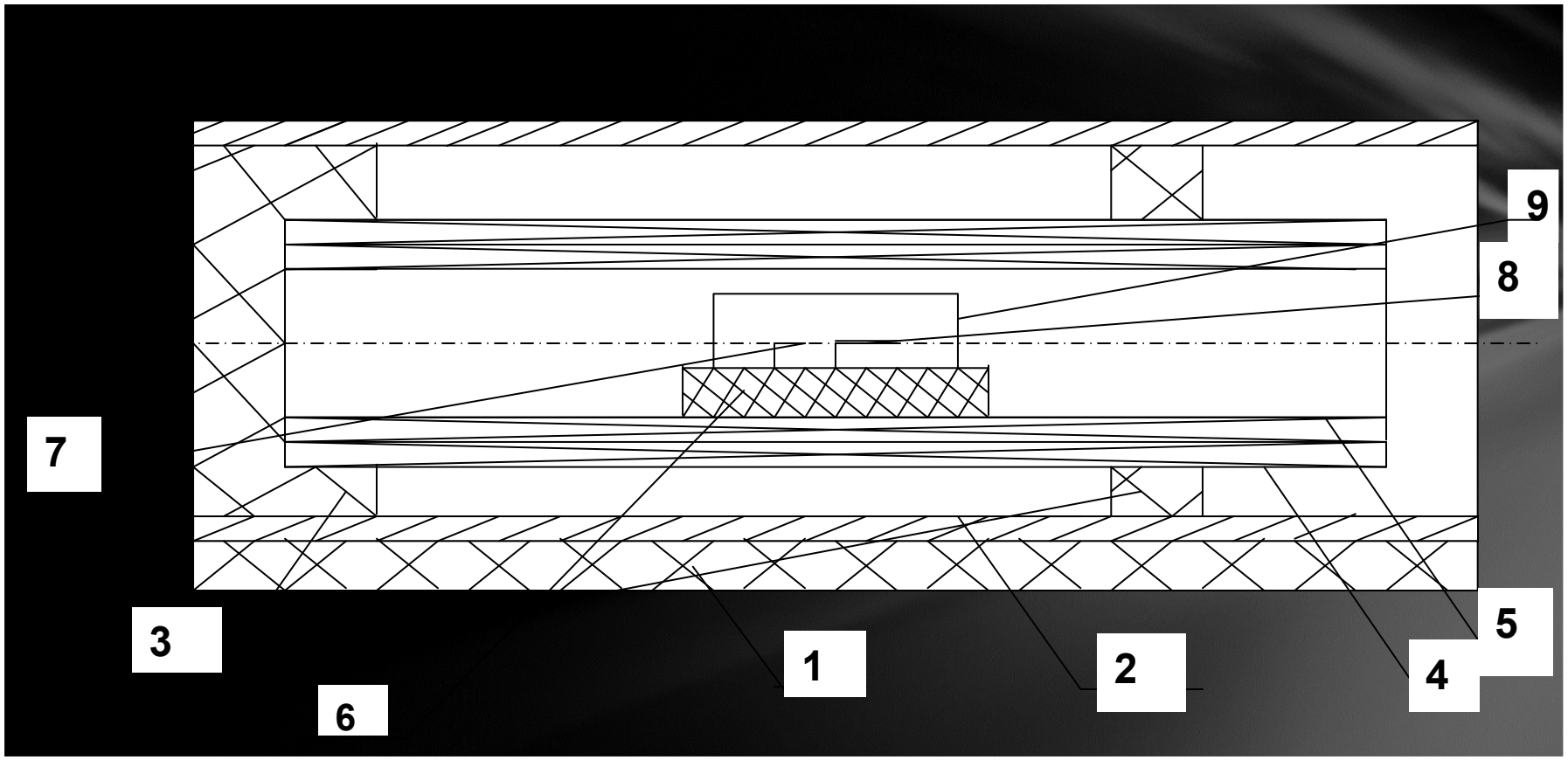
Scheme of experiment

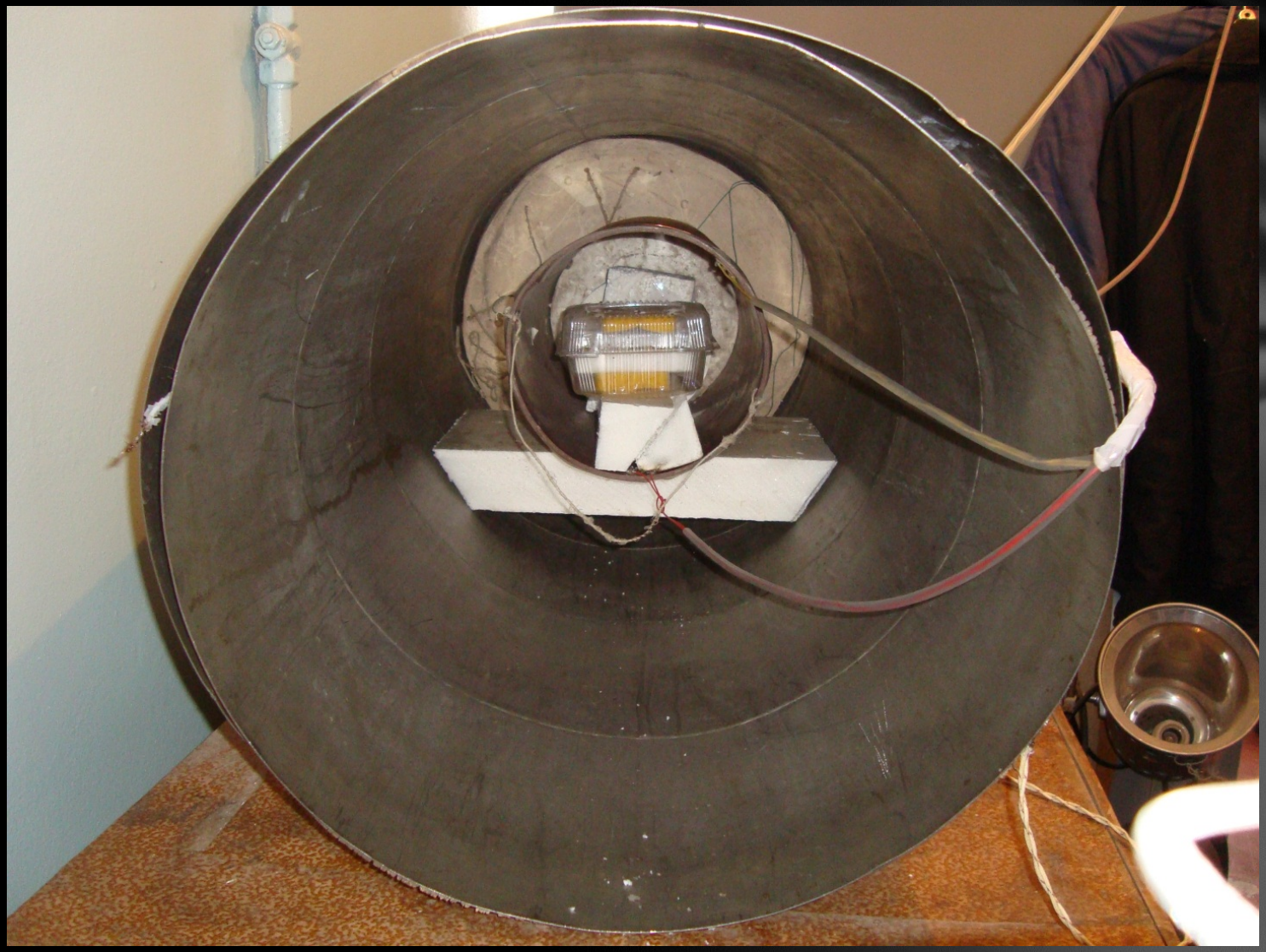


The sight of experimental set in section: 1 – damping rubber; 2 – two layers μ-metal shield with a bottom.; 3 – rings made from non-magnetic material, that centralize the solenoids' coils 4 and 5 relatively the central axis of the shield; 4 and 5 – the coils of solenoids; 6 – the stand of non-magnetic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

Scheme of experiment

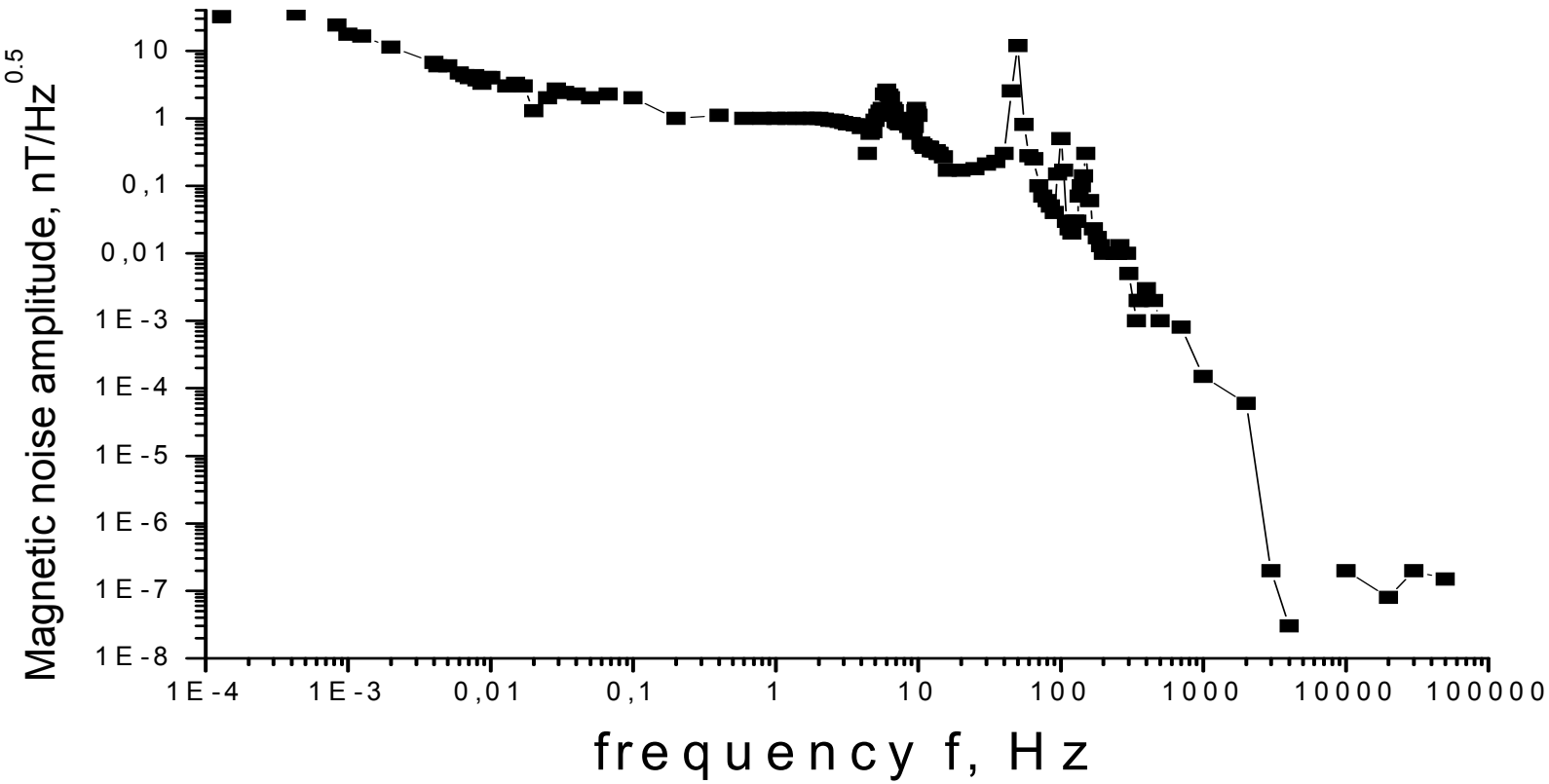
The external sight of the set from the side

Scheme of experiment



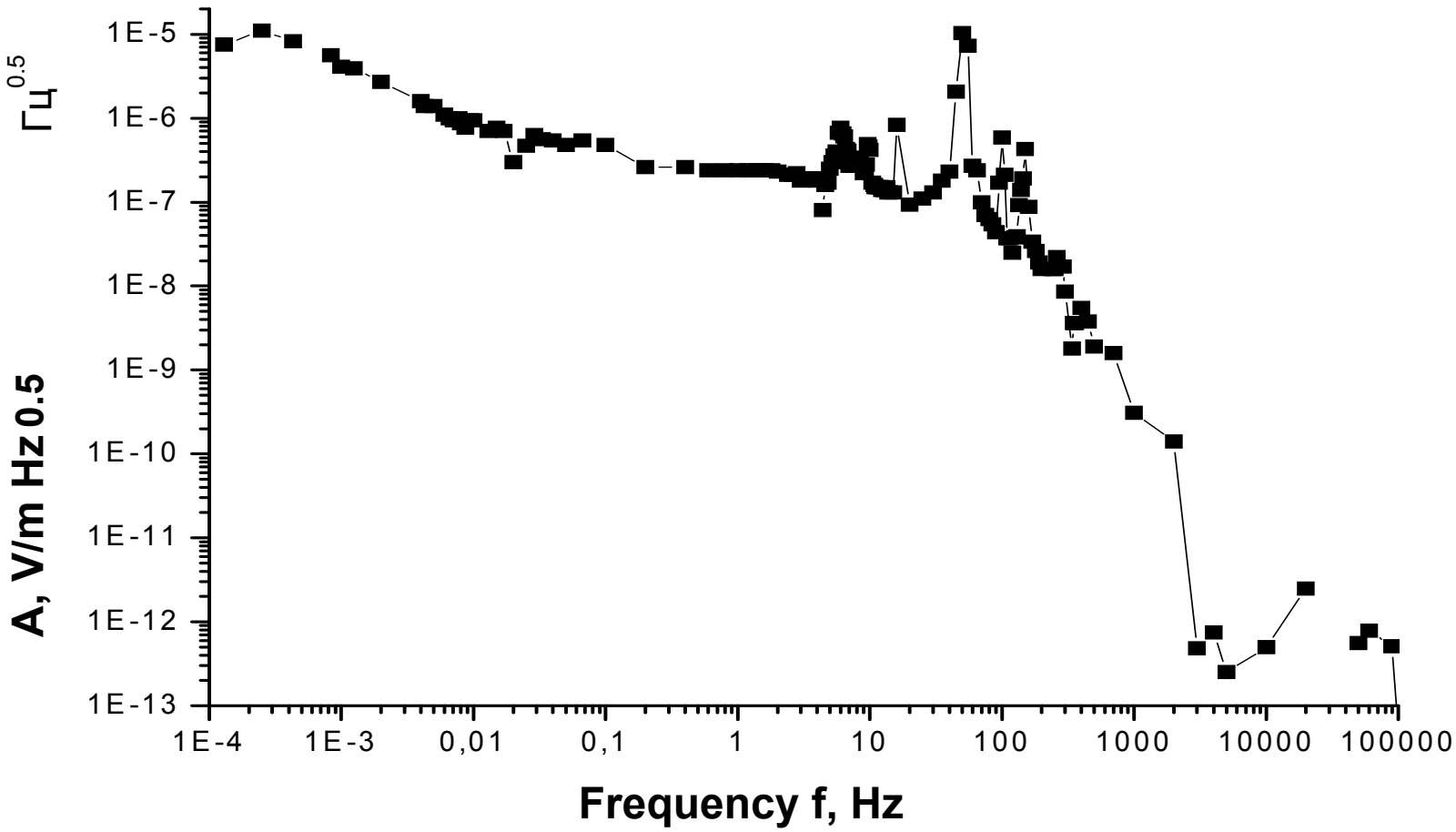
The external sight of the internal part of the set

Preliminary experimental data



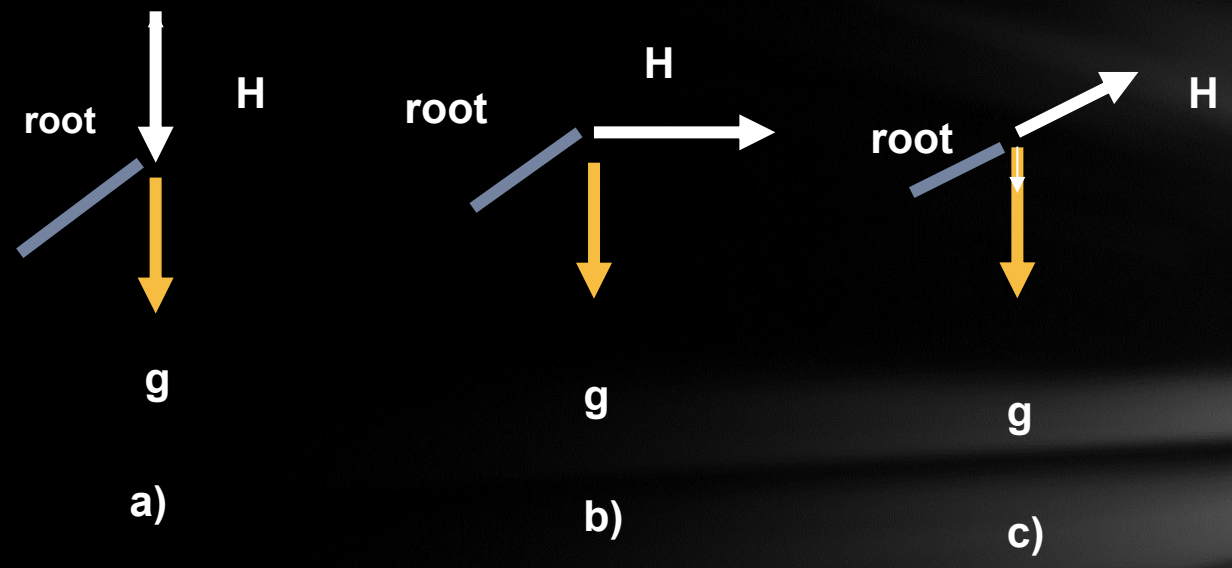
The dependence of amplitude of spectral density of magnetic noise for the system: μ-metal shield + flux gate magnetometer (10^{-4}-100Hz) or μ-metal shield + induction method (16Hz-100kHz). Results of different measurements in the region 16-100Hz coincides between themselves very well

Preliminary experimental data



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

Scheme of experiment



Possible root directions:

a) root ⊥ g, H, g ¶ H the part of roots demonstrates the negative gravitropism;
b) root ⊥ g, H, g ⊥ H the roots don't demonstrate the gravitropism;
c) root ⊥ g, root ¶ H the roots demonstrate normal, but more slow positive gravitropism.
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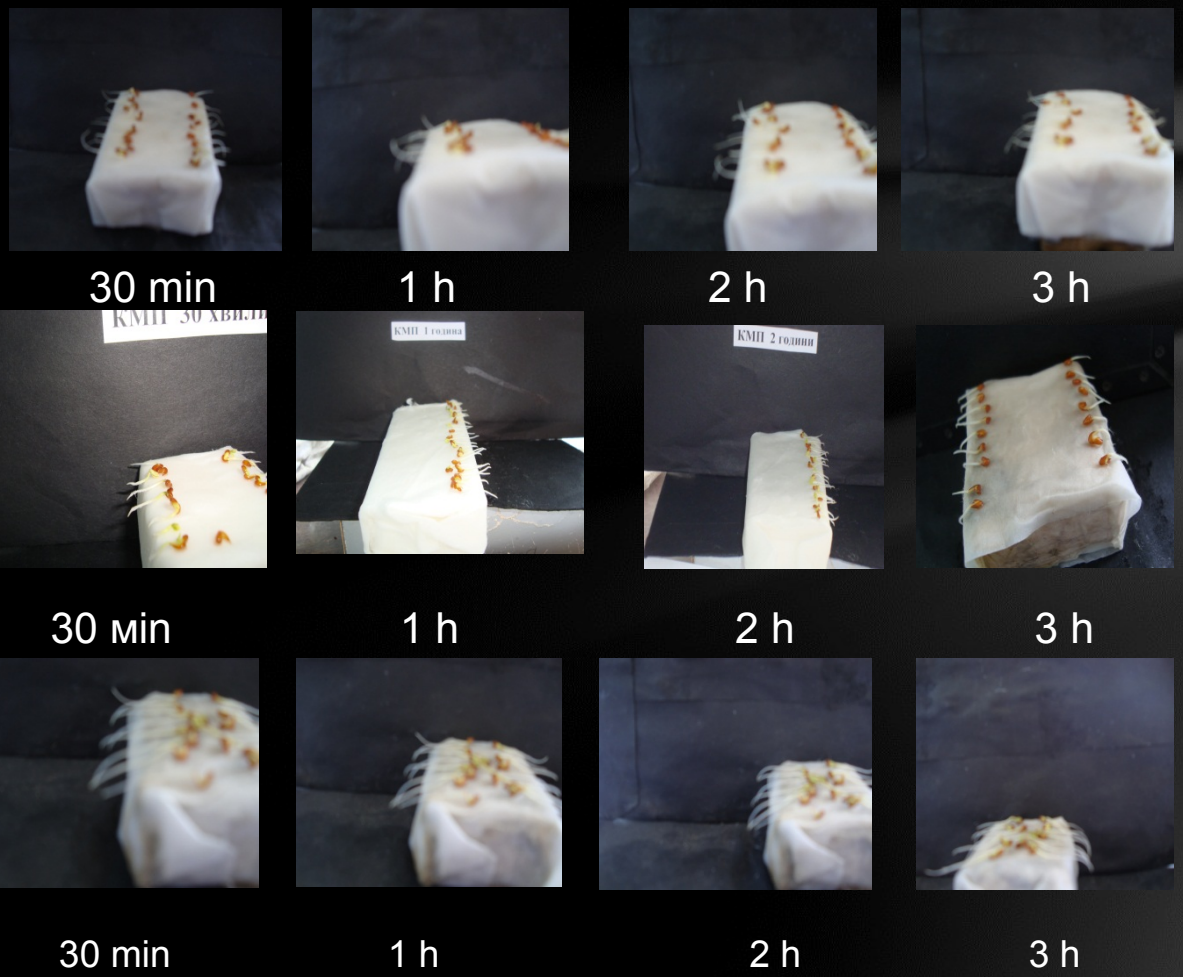
Experimental data



Roots ⊥ CMF

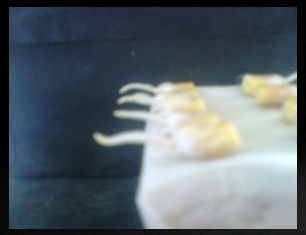
Roots || CMF

SMF

Experimental data

30 min.

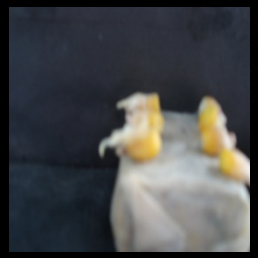
1 h.



2 h.

3 h.

Roots ⊥ CMF,
CMF || **g**



30 min.

1 h.

2 h.

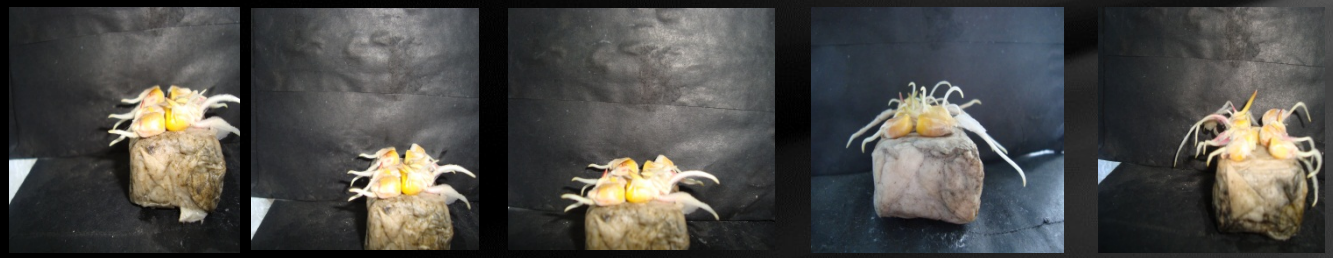
3 h.

SMF

Experimental data

30 min 1 h. 2 h. 3 h. 24 h.

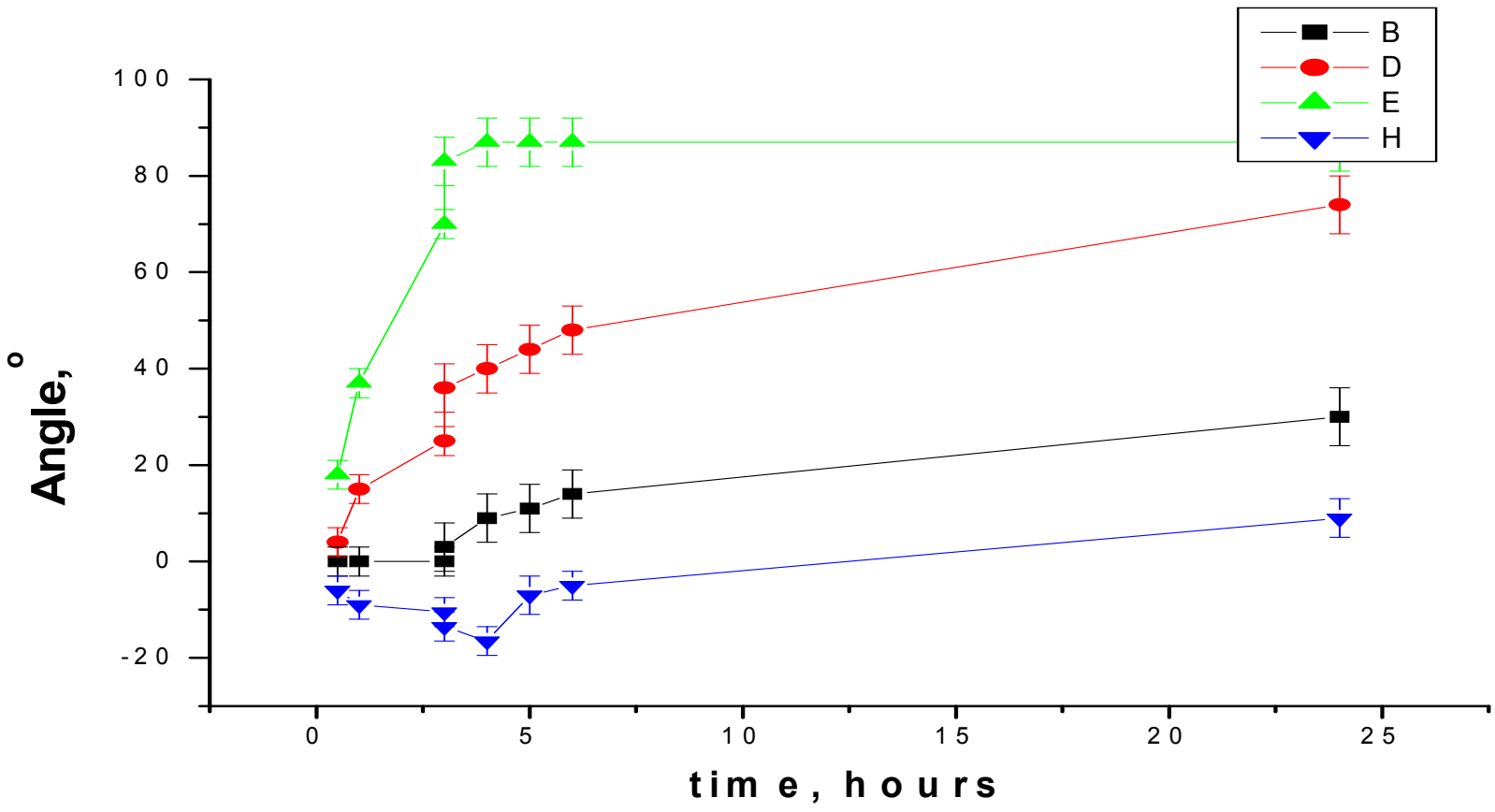
Roots ⊥ CMF



30 min 1 h. 2 h. 3 h. 24 h.

Roots || CMF

Experimental data



Dependence of angle of divergence of maize roots from the horizontal plane on time of the experiment: the blue curve – roots are perpendicular to CMF, CMF is parallel to the gravitropical force; the black curve- the roots are perpendicular to CMF, CMF is perpendicular to the gravitropical force; the red curve – the roots are parallel CMF, CMF is perpendicular to the gravitational force; the green curve is the control in SMF.

Liboff's theory

The equation for ions motion in combined magnetic field Bz and electric field Ex may be written as]:

$m\, dv_x/dt + mv_x/\tau = qE_x + qB_z v_y$

$m dv_y/dt + mv_y/\tau = -qB_z v_x$ (1)

$m\, dv_z/dt + mv_z/\tau = 0$

Here m – ion mass, v – its velocity, τ – time of ion free run (between collisions with any other particles). It is clear that the drift velocity is located in xy – plane and it may be exibited as $v = v_x + iv_y$. Acounting that $B = B_{DC} + B_{AC} \exp i\omega t$ (ω- is the frequency of external magnetic field) we obtaine $dv/dt + 2\beta v = \Gamma - i\Omega (1 + \varepsilon \cos \omega t)\, v$ (2).

Here $\beta = 1/2\, \tau$, $\Omega = qB_{DC}/m$ -cyclotron frequency, $\varepsilon = B_{AC}/B_{DC}$, $\Gamma = \Omega\, E_x/ B_{DC}$.

The solution of equation (2) contains as the components including transient terms that decay in time as well as periodic terms. Considering only resonance-like terms we obtain for velocity in terms of the nth order Bessel series:

$$v = \Gamma \sum_{n=1}^{\infty} J_n (\varepsilon\, \Omega/\omega)\, J_n (\varepsilon\, \Omega/\omega)/ (2\beta + i\omega\, (\Omega/\omega - n)) \qquad (3)$$

For Bessel function of the 1 order (n =1) the velocity of drift is defined by the expression

$$v = \Gamma\, J_1\, 2(\varepsilon)/ 2\beta \qquad (4).$$

When the frequency is not at resonance the drift velocity is

$$v = \Gamma\, J_1\, 2(\varepsilon\, \Omega/\omega)/[\, 2\beta + (\omega 2/ 2\beta)(\, \Omega/\omega - 1)2\,] \qquad (5),$$

For n=1 we have $v = q\, E_x\, \tau\, J_1^{\,2}(\varepsilon)/ m$ (6). Substituting in (6) numeral significances for $E_x = 10^6 - 10^7$ **B** /m, $\tau = 10^{-10}$ s., we obtain for kinetic energy of electron bunch the magnitude 5-20 times exceeding the heat energy of ions.

The formulas (4, 5, 6) obtained by Liboff and al. explain the effects of CMF very well, but they don't explain neighter the threshold effect in static magnetic field nor narrowing the line of dependence of effect on the B_{AC}/B_{DC} at small noise level of B_{DC}.

OUR HYPOTHESIS

Results obtained may be interpreted in the following way. At first we give an account our understanding of CMF influence on the gravitropic reaction of plants. We use the hypothesis We use the hypothesis that GTR is connected with the pressure of heavy cell's elements on the membrane in the lower part of the cell. And these leads to the break of cell's membrane in its down part and to form channels for directed ions transport.

Such a supposing may explain the series of effects observed. The static component of CMF makes all ions (from the sign of the charge depends only the direction of rotation) to rotate around the magnetic field direction in one or other side. Any collisions lead only to the change of radius of rotation, but not the frequency changes. The rotation leads to the creation of centrifugal forces and so it leads to the increasing of pressure on the cell membrane. The adding of the alternative component of magnetic field to the static component have to lead to the creation of membrane oscillations with the frequency that is equal to the frequency of the alternative component of CMF. These may lead to the additional breaking of membrane in the region of maximum pressure and additional directed ion transport through the new-coming channels. In CMF these channels may be located not only at the place where the most heavy particles are located in the cell, that is at the bottom of the cell. So it may lead to the changing of the direction of ions transport and the sign of GTR.

The change of channel's quantity leads to the change of GTR velocity. But resonances effects have to be observed at the frequencies of initial oscillations of membrane caused by gravitational force. The estimation of these frequencies gives us the value of frequency of the order 10^6 - 10^7 Hz. The estimation of the pressure value caused by starch gains is equal to (0.3 –5) 10^{-5} H/m^2 , Analogous calculations for the pressure, caused on the cell's membrane by the centrifugal force, caused by the ion rotation in CMF give the value of the same order (0.1 -0.5) 10^{-5} H/m^2.

OUR HYPOTHESIS

So the new channels may be created in membrane and in the direction perpendicular to the gravitation force, if the direction of Lorentz forces perpendicular to the gravitation force.. Besides the presence of alternative component of CMF has to lead to the oscillations of pressure and membrane tension in the direction that may be perpendicular to the gravitation force. This has to lead to oscillations of ion channels dimensions and to changing of ion transport.

But such a little changes of pressure cannot be the reason of creation of new channels. If we take into account the pressure of ions on the membrane's wall in electric field (It's value is about 10^7 H/m^2) we obtain a very stretched membrane. The adding pressure is connected with the rotation of ions and even it's small values may lead to the creation of new channels in membrane , moreover in the direction perpendicular to CMF. If CMF is parallel to the gravitation force new channels are created in the direction that is perpendicular to the gravitation force.. Besides, the adding of the alternative component of magnetic field to the static component have to lead to the creation of pressure oscillations and so to membrane oscillations with the frequency that is equal to the frequency of the alternative component of CMF and it's tension in the direction perpendicular to CMF. And this leads to oscillation of ion channels dimensions and their pass capacity. The estimation of the Ca^{2+} channel tension gives us the magnitude 10 – 100 nm, that is more then it's dimension 0.3 -0.7 nm. The frequency of membrane oscillations is equal to the frequency of the alternative component of CMF. The dimension of ion bunch oscillates too because of divergence of ions of their primary direction in magnetic field. The frequency of ion bunch dimension oscillation is equal to cyclotron frequency. The resonance of these two processes is possible.

OUR HYPOTHESIS

The maximum pressure of ions on membrane's wall has to be in magnetic field directed perpendicular to the flux of ions that take part in the biological process that is studied. The presence of such a field leads to creation of new channels in the direction that is perpendicular to the static magnetic field and parallel to the direction of ions transport or to the increasing of the channels dimension. Such an action has to lead to the threshold effects arising.

CMF leads to the creation of membranes oscillations in the direction that is perpendicular tj the CMF direction with the frequency that is equal to the frequency of the alternative component of CMF. The radius of ions bunch oscillates with the cyclotron frequency. When both frequencies coincide with each other the ions flux through membrane increases. This fact leads to the biological effect.

Our hypothesis works only while using Liboff's supposition that the key role plays electric field of membrane.

Explanation of experimental results

Both Liboff's and ours theories give the essential dependence of biological effects on the direction of determined ions transport. So the results obtained by us may be explained in the following way, The main direction of Ca^{2+} ions flux is along the root: parallel to the direction of its growth. We have to notice here that if the basic direction of ions transport is located along the direction of CMF, then the biological effect has not to be observed. This is observed in the experiment.

Now we'll try to explain the location of starch grains in CMF, investigated by us before. The membrane oscillations may push the starch grains to the cell's center and even further. Then if the grains even begin to settle they come to the opposite part of the cell and consequently may change the sign of GTR of root. Besides, collisions of starch grains with the flux of Ca^{2+} ions have to lead to creation of dipole moment (piezoelectric properties of starch), that is directed against the electric field of membrane, that may lead to their movement to the cell's center. The energy of the starch grains in the center of the cell is minimal. While moving to the center the part of dipole moments begin to turn and may begin to move up, that will lead to negative GTR for roots.

So in CMF the GTR has either to disappear or to change its sign or to reduce its speed if the ion flux is directed perpendicular to CMF.

Magnetic field shielding

It is clear now the influence of external magnetic field shielding on different biological processes Besides the effect connected with the decreasing of the static component of external magnetic field the influence of magnetic noise has to increase. For instance while compensating the static component by means of Helmgolts coils or usual ferromagnetic shields down to 10 – 1μT the ratio B_{AC}/B_{DC} at the frequency 50 Hz is equal approximately 0.3 – 3. So the frequencies up to 50 Hz may act actively on the biological processes because of the most part of resonance frequencies (for Ca, Mg, K, Cu ions) is disposed in this region. Magnetic storms for these experiments are active too. So the decreasing of the magnetic field of the Earth is very undesirable factor that may change essentially Ca, K, Mg exchange in the cell. It is particularly important for the weak cells that have the easily broken membranes

Cells adaptation in CMF

Cell adaptation mechanism in CMF is proposed. As it is clear from the dependence of the angle of curvature on time GTR (after 24 hours and more) begins to restore its sign. The increasing of Ca^{2+} ions transport from the cell may lead the relative concentration of Mg^{2+} ions increases . Because the Mg^{2+} ions are the catalyzes of lipids synthesis the coefficient of membrane hardness changes. We notice here that the cyclotron frequency of Mg^{2+} ions in the static magnetic field of the Earth is near 50 Hz. It was shown by Novitsky with coauthors that in CMF with the static component that was equal to the Earth's one and the alternative component with the frequency that was equal to 50 Hz, that was created artificially, the concentration of polar lipids in the membrane of radish cells changed essentially. And the fluidity of the membrane changed. So the decreasing of the membrane hardness while Ca^{2+} ions concentration in the cell decreases may lead to the decreasing of the quantity of Ca^{2+} channels and following to the increasing of Ca^{2+} ions concentration in the cell. That is the effect of adaptation.

CONCLUSIONS

1. It was shown experimentally that the gravitropic reaction of plants depended essentially on the direction of roots relatively combined magnetic field. When the roots were located perpendicular to CMF and gravitational force (CMF was parallel to the gravitational force) the negative gravitropic reaction was observed. When the roots were located perpendicular to CMF and gravitational force (CMF was perpendicular to the gravitational force) the gravitropic reaction was absent. When the roots were located parallel to CMF and perpendicular to the gravitational force (CMF was perpendicular to the gravitational force) gravitropic reaction changed insignificantly.
2. The effects obtained in this work and in many other works beforehand coincided very well both with the Liboff's hypothesis and ours. Using them we may confirm that the main flux of ions was directed along the roots.
3. The essential role for observation of biological effects of CMF plays the electric field of cell membrane. Taking in account its magnitude one may deny all objections of physics about impossibility of magnetic field biological action because of its small energy. SMF and CMF are only the mechanisms that release the cell energy and lead to biological effects.

THANK YOU FOR ATTENSION!