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INFLUENCE OF ALTERNATIVE ELECTRIC FIELDS OF DIFFERENT DIRECTIONS ON THE CRESS ROOTS GRAVITROPIC REACTION IN HORIZONTAL STATIC MAGNETIC FIELD

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The gravitropic reaction of cress roots was investigated in static horizontal magnetic field and alternative electric field of different directions. The alternative electric field was tuned to cyclotron frequency of Ca^{2+} ions in horizontal static magnetic field. Six different variants were investigated. In the first variant the alternative electric field was parallel to magnetic one and roots were perpendicular to both of them. In the 2-nd variant the electric field was perpendicular to magnetic one and parallel to g, the roots were perpendicular to all of them. In the 3-d variant the electric field was perpendicular to magnetic one and parallel to magnetic one and roots were parallel to magnetic field. In the 4-th variant the electric field was perpendicular to both the magnetic field and g and the roots were parallel to magnetic field. In the 5-th variant the electric field was perpendicular to both the magnetic field and g and the roots were parallel to magnetic field. In the 6-th variant the electric field was perpendicular to both the magnetic field and g and the roots were parallel to electric field. The essential inhibition of gravitropic reaction has been observed only in the first variant. In the 6-th variant the essential decreasing of gravitropic reaction has been observed only at the beginning.

Keywords: static magnetic field, alternative electric field, gravitropic reaction, roots direction, cyclotron frequency.

INTRODUCTION

The investigation of combined magnetic field (CMF, static and parallel to it alternative magnetic field) influence on the plants roots gravitropic reaction was studied in details before for different relative orientation of fields and roots [1–4]. It was shown that the effect developed essentially on the orientation of roots relatively the CMF[3]. It was shown that the roots direction relatively B_{DC} and B_{AC} (B_{DC} and B_{AC} are inductances of static and alternative magnetic fields) are essential for negative gravitropic reaction and decreasing of gravitropic reaction observation [4]. The effect we obtained may be explained by our theory based on Liboff's hypothesis (the electric field was taken in consideration) and ours previous work [3, 4]. The breathing of the membrane is important only in the cases when the ions direction of moving is not parallel either for B_{DC} or B_{AC} .

To confirm or deny our hypothesis we changed [5, 6] the alternative component of magnetic field by alternative electric field of different orientations. In the works [5, 6] the following variants of roots location relatively to static vertical component of magnetic field and alternative component of electric field were studied.

■ At first variant the static magnetic field was directed parallel to the gravitation vector, the alternative electric field was directed parallel to static magnetic field, roots were directed perpendicular to both two fields components and gravitation vector;

■ At second variant the static magnetic field was directed parallel to the gravitation vector, the alternative electric field was directed perpendicular to static one, roots were directed parallel to alternative electric field;

■ At third variant the static magnetic field was directed parallel to the gravitation vector, the alternative electric field was directed perpendicular to static one, roots were directed perpendicular to both two fields components and gravitation vector.

It was shown, that at the first and second variants the speed of gravitropic reaction was decreased essentially while at the third variant didn't not differ from the control experiment. The biological effect was observed only for the amplitude of alternative electric field 100V//m. We didn't observe any effect at the amplitude of alternative electric field 10V//m. We have to notice here that it was impossible to determine the exact value of amplitude of alternative electric field because of the wet environment. It depended on the humidity of the camera and the electric resistance of the root.

To have the whole picture of the effects we observed the analogous investigation in the horizontal static magnetic field has been fulfilled.

The following variants of roots location relatively the static horizontal magnetic field and alternative electric field were investigated. In all variants the static magnetic field with magnetic inductance B_{DC} was directed perpendicular to the gravitational vector g..

In the first variant the electric field was parallel to magnetic one and the roots were perpendicular to both of them..

In the 2-nd variant the electric field was perpendicular to the magnetic one and parallel to the gravitropical vector g, the roots were perpendicular to both fields.

In the 3-d variant the electric field was perpendicular to magnetic one and parallel to g, the roots were parallel to magnetic field.

In the 4-th variant the electric field was parallel to magnetic one and roots were parallel to both of them.

In the 5-th variant the electric field was perpendicular to both the magnetic field and g and the roots were parallel to magnetic field.

In the 6-th variant the electric field was perpendicular to both the magnetic field and g and the roots were parallel to electric field. B_{DC} .

MATERIALS AND METHODS

To obtain the horizontal magnetic field it was necessary to turn the settings that had been drawn on fig 1 and 2 in the works [5, 6] on the side by the same way as in the work [3]. Then the axes of the shield and the solenoid became horizontal. In that case the setting shown on fig 1 {works 5, 6} create horizontal electric field and the setting shown on fig 2{works 5, 6} create vertical electric field. The dependences of magnetic field and electric fields noises on the frequency were similar to the decencies shown on fig 3 [5, 6]. But the amplitudes of spectral densities of magnetic and electric fields noises was approximately by two times less.

RESULTS AND DISCUSSION

The results obtained were shown on fig. 1 and 2.

First variant





b

Second variant





Third variant











Sixth variant



Fig 1. The gravitropic reaction of cress roots for 0.5 (a, c, e, g, I, k) and 1 hour (b, d, f, h, j, l). The value of static magnetic field induction was equal to 40μ T, the frequency of alternative electric field was equal to 31.75 Hz, and the amplitude of electric field was equal to 100 V/m.



Fig. 2. Dependence of cress roots angle of divergence from the horizontal place on. Magnetic field was directed perpendicular to gravitational vector g. Curve B corresponds to the first variant (variant the electric field was parallel to magnetic one and the roots were perpendicular to both of them.); curve D corresponds to the second variant (the electric field was perpendicular to the magnetic one and parallel to the gravitropical vector g, .the roots were perpendicular to both fields); curve F corresponds to the third variant (the electric field was perpendicular to magnetic one and parallel to g, the roots were parallel to magnetic field); curve H corresponds to the forth variant (the electric field was perpendicular to both second so the forth variant (the electric field was perpendicular to both were parallel to both of them); curve J relates to the fifth variant (the electric field was perpendicular to both the magnetic field and g and the roots were parallel to magnetic field); curve L relates to the sixth variant (the electric field was perpendicular to both the magnetic field and g and the roots were parallel to both the magnetic field and g and the roots were parallel to both the magnetic field and g and the roots were parallel to both the magnetic field and g and the roots were parallel to electric field was perpendicular to both the magnetic field and g and the roots were parallel to electric field was perpendicular to both the magnetic field and g and the roots were parallel to electric field was perpendicular to both the magnetic field and g and the roots were parallel to electric field was equal to 31.75 Hz, and the amplitude of electric field was equal to 100 V/m.

It was clear from fig. 1 and 2 that the main condition under which the gravitropic reaction inhibition was observed was the following. The roots needn't be parallel to the static magnetic field.

The results obtained in this work confirm the results of our previous works [3, 4]. It was shown in the works [3, 4] that the biological effect on gravitropic reaction existed only in the cases when the roots direction was perpendicular to static or alternative magnetic fields or to both of them. In this work we showed that the same effect existed. The gravitropic reaction was sensitive to simultaneous action of static magnetic field and alternative electric one only when the roots direction didn't coincide neither with the

direction to static magnetic field nor with the direction of alternative magnetic field created by alternative electric field. This result coincides well with the results of previous works [3–7] and confirmed the fact that the main direction of Ca^{2+} ions' moving was the moving along the roots. The results obtained in horizontal magnetic field confirmed the results obtained in vertical magnetic field.

The absence of gravitropic reaction changes in the cases when the roots direction of growing coincided with the static magnetic field direction showed that the direction of ions moving is important. In the case when there was no preferred ions moving direction the effect might be absent or decreased essentially. These argument may explain the difference between results obtained for different fulfilling of one and the same experiment. For instance the changes of gravitropic reaction were much smaller when the roots were growing on the sponge comparing with the results when the roots were growing in the air [8].

The effect we obtained may be explained by our theory based on Liboff's hypothesis [7] (the electric field of membrane was taken in consideration) and ours previous works. The breathing of the membrane is important only in the cases when the ions direction of moving is not parallel either for BDC or BAC. Here BAC is the alternative magnetic field created by alternative electric field.

We have to notice that while the gravitropic reaction is absent, the roots become thicker. The effect may be connected with water detained in roots.

CONCLUSIONS

- 1. The direction of roots relatively both static magnetic field and alternative electric field is very important.
- 2. The effect has the physical nature and may be explained by membrane breathing caused by alternative electric field.

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INFLUENCE OF ALTERNATIVE ELECTRIC FIELDS OF DIFFERENT ...

 Шейкина Н. В. Зависимость гравитропической реакции кресс-салата от амплитуды переменной составляющей комбинированного магнитного поля / Н. В. Шейкина, Н. И. Богатина, Е. Л. Кордюм // Біофізичний Вісник (Вісник Харківського университету). – 2007 – №18(1) – С. 78–90.

Шейкина Н. В. Влияние переменных электрических полей различных направлений на гравитропическую реакцию корней кресс-салата в вертикальном постоянном магнитном поле / Н. В. Шейкина // Ученые записки Крымского федерального университета имени В. И. Вернадского. Серия «Биология, химия». – 2015. – Т. 1 (67), №3. – С. 81–87.

Исследовалась гравитропическая реакция корней кресс-салата в постоянном горизонтальном магнитном поле и переменное электрическом поле различных направлений. Переменное электрическое поле настраивали на циклотронную частоту ионов Ca^{2+} в горизонтальном магнитном поле. Опыт проводился при шести различных относительных направлениях магнитного, электрического полей и корней. В первом варианте электрическое поле параллельно магнитному, а корни перпендикулярны им обоим; во 2 варианте электрическое поле перпендикулярно магнитному и параллельно вектору гравитации, корни параллельно вектору гравитации, корни параллельно магнитному полю; в 4 варианте электрическое поле перпендикулярно магнитному полю; в 6 варианте электрическое поле перпендикулярно ослабление гравитации, корни параллельны электрическому полю. Значительное ослабление гравитропической реакции наблюдается лишь в 1 варианте. В 6 варианте значительное

Ключевые слова: постоянное магнитное поле, переменное электрическое поле, гравитропическая реакция, направление корней, циклотронная частота.