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FORMATION OF MAGNETIC PROPERTIES IN BIOLOGICAL SYSTEMS UNDER STRESS FACTORS

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Abstract: The article is devoted to the study of the effects of stress factors such as ionizing gamma radiation and ultraviolet radiation on some plant samples. The studies were conducted using the Electronic Paramagnetic Resonance (EPR) method. Spectrums of the studied plant samples were registered at room temperature. The signals characterizing of magnetic nanoparticles were observed in stress-exposed samples. Characteristics of EPR signals of biogenic magnetite and forms of their collection have been determined.

Keywords: biological system, magnetic properties, EPR signals, magnetic nanoparticles, stress factors.

1. Introduction

It is known that live matter consists of natural iron oxide nanoparticles which are formed as a result of biomineralization. Biomineralization of magnetite (Fe3O4) is a genetically controlled biochemical process. During biomineralization, perfect ferrimagnetic crystals form in the living organism. The most spreading magnetic nanoparticles in living and non- living nature are magnetite and magmatite (γ-Fe2O3). They play an important role in the functioning of living systems, as well as in the development of pathological conditions [1,2]. The mechanism of magnetite formation is not yet known. However, there are various opinions. It is assumed that ferritin protein is involved in magnetite formation and that magnetite is an intermediate product in the formation of ferrihydrite crystalline's nucleus. It has also been shown in an experience that, magnetic nanoparticles can be formed from Fe ferritin ions with the presence of DNA and can participate in biomineralization processes in living systems [3-6].

In our experiments, we found that these nanoparticles cause magnetic properties in biological systems and the first time it was detected that it causes the broadest EPR signal in plants [7,8]. The present paper aimes to investigate the mechanisms of action of stress factors on the formation of biogenic origin nanophase particles in natural living systems.

2. Materials and methods

Researching objects in the experiments were seeds of wheat (Triticum Vulgare), beans (Phaseolus L.), maize (Zea mays), and juniper which is one of the medicinal plant (Juniperus communis). As stress factors, the effects of ionizing gamma radiation and ultraviolet (UV) radiation on plants were studied.

Seeds were irradiated at different doses (10 Gy, 50 Gy, 100 Gy, 150 Gy, 200 Gy, 300 Gy) and were grown at room temperature (Figure 1). Irradiation with gamma radiation of the samples was carried out on the device K-25. The source of radiation was isotopes 60Co and 57Co.

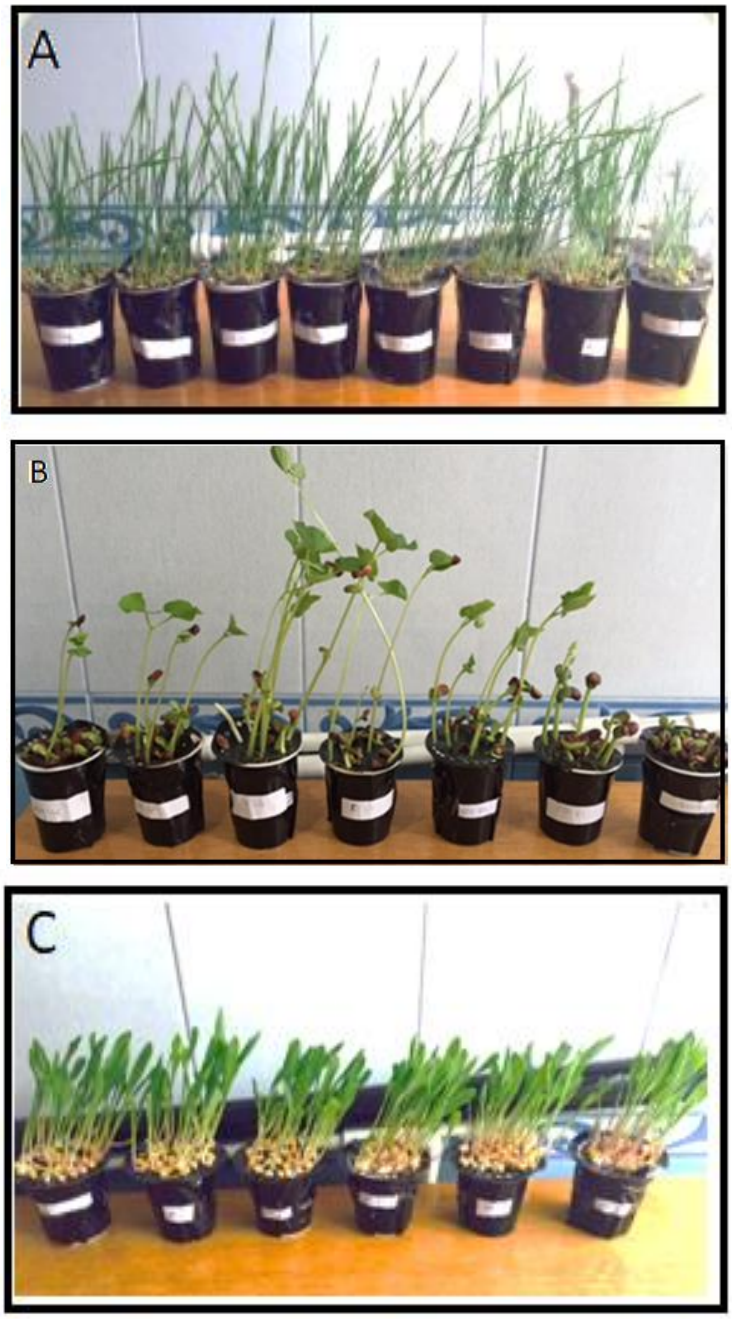

Fig. 1. 10-day sprouts of seeds irradiated at different doses by ionizing gamma radiation. A-wheat, B-beans, C-corn.

The EPR spectrums were registered on an X-range Bruker ECS-106 EPR spectrometer at room temperature (293K) and at liquid nitrogen temperature (77K). When studying the effects of UV radiation, the samples were irradiated using high-pressure DRT-230 mercury-quartz lamps. The UFS-2 filter was used in experiments to obtain environmental UV rays.

3. Conclusion and discussion

As mentioned above, the presented work has investigated the effects of ionizing gamma radiation and ultraviolet radiation on living systems as stress factors.

After 10-day sprouts of irradiated seeds of the above-mentioned plants were dried at room temperature, EPR spectra of samples were registered and their characteristics were studied.

Based on these characteristics, the method of detection and identification of crystalline iron oxide nanoparticles has been developed by the EPR method for use in biomedical research and medical diagnostics.

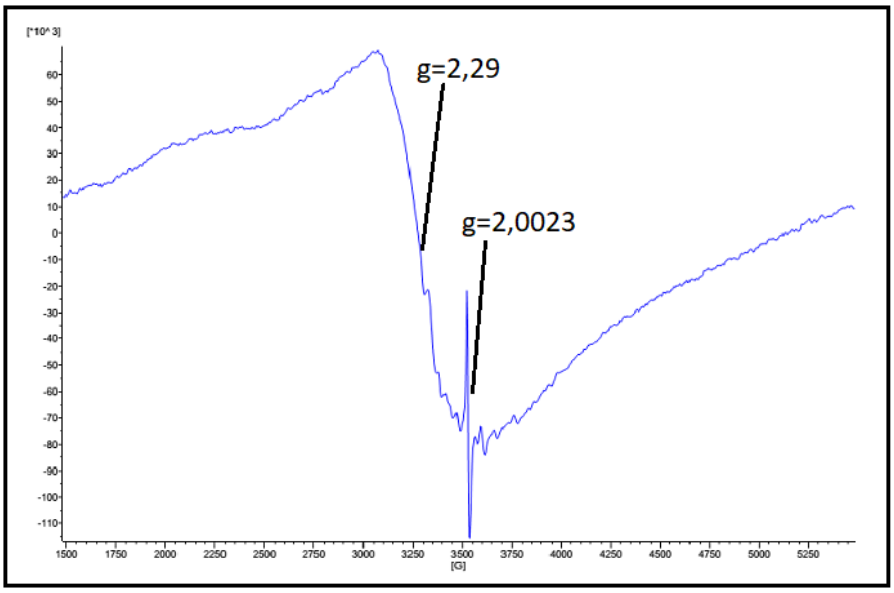

Fig.2. EPR spectra of sprouts of wheat seeds irradiated at 200 Gy

As shown in Figure 2, at a certain radiation value (100, 200 Gy), a broad EPR signal (g= 2.29; ΔH = 320 Gs), characterizing iron oxide magnetic nanoparticles, was recorded in the samples. As another stress factor, the effects of UV radiation have also been studied (Figure 3).

Fig.3. UV-irradiated sprouts of wheat and corn seeds

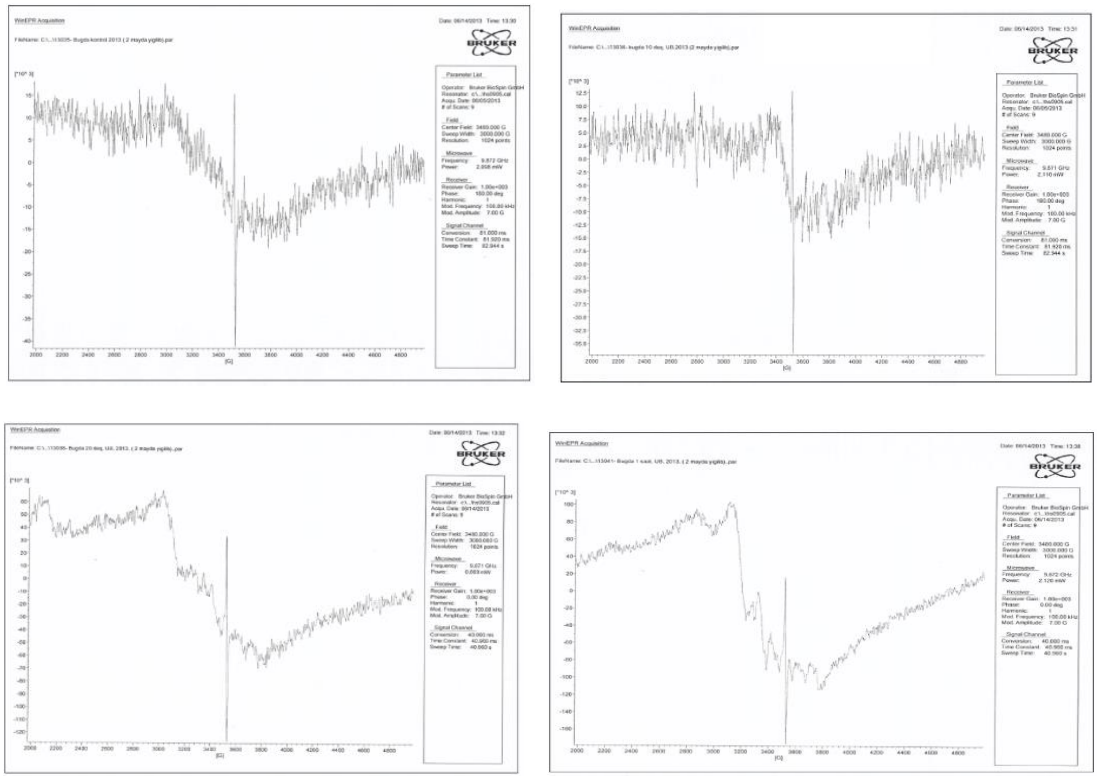

Fig.4. EPR signals of dried samples of wheat seedlings exposed to UV radiation at different doses

It was found that during the exposure to UV radiation, two types of signals are observed in the EPR spectrums of leaf samples (Fig. 4). One of these is a narrow signal corresponding to g = 2.0 and corresponds to the signal of free radicals. The other is an intensive signal corresponding to g = 2.32.

The parameters of the signals which we receive during stress (g = 2.32, ΔH = 500 Gs) allow us to assume the existants of iron oxide magnetic nanoparticles in these leaves. Thus, it is found that the signal which we receive due to the parameters corresponds to the magnetic nanoparticles.

We investigated the EPR signals of plants by changing radiospectrometer parameters to investigate the specific broad EPR signal characteristic of iron oxide nanoparticles and found that this signal had magnetic anisotropy.

So that, for determine the variation of the angle in the resonator, when we were investigating at different angles (90º, 180º, 270º, 360º) the glass ampoules where samples are placed, we observed that the shape of EPR signal changes slightly and moved slightly to the left. This behavior of the signals has been found for the superparamagnetic nanoparticles Fe3O4 and γ-Fe2O3. This indicates that the paramagnetic centers in charge of the EPR signal have complex structures.

At the same time, we investigated the medicinal plant Juniper *(Juniperus communis).* Spectra of the seeds, shells, and also seeds and shells together were registered. In the recorded spectra, we observed two types of signals obtained in biomaterials. One of these is the EPR signal received when g = 2.01. This signal is characterized by a six-component structure in enzymes containing Mn. This signal was observed only in the seeds of the Juniperus communis plant. At the same time, at g = 2.28, we observed a broad EPR signal, characteristic of the

paramagnetic species SPION particles (superparamagnetic iron oxide nanoparticles). This signal was observed in the shells of the seeds. It should be noted that SPIONs which found here play an important role in the development of pathological conditions and are mainly used for biomedical applications [9,10]. These magnetic nanoparticles cause magnetic properties in plant systems and lead to the formation of a characteristic EPR signal.

Research has shown that magnetic nanoparticles are as much presence in natural systems as well as in living systems. However, any stress factor and the pathological condition leads to the biogenic generation of nanophase magnetic nanoparticles.

For the first time, we found that under the influence of the stress factors anomalous magnetic properties occur in living systems. Characteristics of EPR signals of biogenic magnetite and forms of their collection have been identified.

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ФОРМИРОВАНИЕ МАГНИТНЫХ СВОЙСТВ В БИОЛОГИЧЕСКИХ СИСТЕМАХ ПОД СТРЕСС ФАКТОРАМИ

А.Н. Насибова

Резюме: Статья посвящена изучению влияния таких стресс факторов, как ионизирующее гамма-излучение и ультрафиолетовое облучение, на некоторые образцы растений. Исследования проводились методом Электронного Парамагнитного Резонанса (ЭПР). Спектры исследуемых образцов растений регистрировали при комнатной температуре.

В образцах, подвергшихся стресс факторам наблюдались сигналы, характеризующие магнитные наночастицы. Определены характеристики сигналов ЭПР биогенного магнетита и формы их суммирования.

Ключевые слова: биологическая система, магнитные свойства, сигналы ЭПР, магнитные наночастицы, стресс факторы.

STRES AMİLLƏRİN TƏSİRİ ZAMANI BİOLOJİ SİSTEMLƏRDƏ MAQNİT XASSƏLƏRİNİN YARANMASI

A.N. Nəsibova

Xülasə: Məqalə stress amillərdən ionlaşdırıcı qamma radiasiyanın və ultrabənövşəyi şüalanmanın bəzi bitki nümunələrinə təsirinin tədqiqinə həsr edilib. Tədqiqatlar Elektron Paramaqnit Rezonans (EPR) metodu ilə aparılıb. Otaq temperaturunda tədqiq olunan bitki nümunələrinin spektrləri qeydə alınıb. Stresə məruz qalmış nümunələrdə maqnit nanohissəciklərini xarakterizə edən siqnallar müşahidə edilib. Biogen maqnetitin EPR siqnallarının xarakteristikaları və onların toplanmasının formaları müəyyən edilmişdir.

Açar sözlər: bioloji sistem, maqnit xassələri, EPR siqnalları, maqnit nanohissəcikləri, stress amillər.