ELECTROMAGNETIC TECHNOLOGY OF INCREASING THE YIELD OF SUNFLOWER

Mariia Chorna
PhD
Department of Biomedical engineering and theoretical electrical engineering[1]
tte_nniekt@ukr.net

Dmytro Milenin
Department of Automation of Electromechanical systems[1]
[1]*Kharkiv Petro Vasylenko National Technical University of Agriculture*
44 Alchevskih str., Kharkiv, Ukraine, 61012

Abstract: The article solves the problem of obtaining scientifically based practical and experimental results of increasing the yield and oil content of sunflower seeds, based on the use of information EMF of EHF range for pre-sowing treatment of seeds.

The study of the biophysical effects of the electromagnetic field on sunflower seeds was carried out in order to determine the biotropic parameters of the electromagnetic field, which have a stimulating effect on the seeds. For this, a mathematical model of a sunflower seed in the form of a spheroid was developed.

For the calculations, the following frequency range of the exciting wave 25–40 GHz was chosen. The choice of this range is due to two circumstances. First, the relative dielectric constant of sunflower seeds in this range practically does not have frequency dispersion. Secondly, the wavelength is commensurate with the characteristic geometrical sizes of the seeds and, therefore, the intensity of the excited electric field inside the seeds resonantly depends on the frequency.

The measurement of chemiluminescence was chosen as the response of the biological object. For registration of extremely weak light fluxes of seeds, the photon counting method was chosen, which made it possible to carry out effective measurements of both spontaneous biochemiluminescence and induced information EMF. As a result of theoretical and experimental studies, a system was developed for measuring the chemiluminescence of seeds.

The purpose of the experiment was clarification of the optimal biotropic parameters of the information EMF, which would provide an increase in yield and quality of sunflower seeds when they are irradiated with EMF. The result of field tests showed the advantage of using electromagnetic technology over other methods of pre-sowing treatment of seeds.

Keywords: electromagnetic technology, biotropic parameters, sunflower seeds, electromagnetic field, resonator system.

1. Introduction

Currently in Ukraine, the average yield of agricultural crops has decreased by 20...25 %, including sunflower, due to the high cost and lack of mineral fertilizers and plant protection products from pests. Therefore, the urgent task is the development of new cost-effective, efficient and environmentally friendly technologies aimed at increasing yields.

One of the ways to solve this problem is use of the information EMF of the EHF range. Studies show that the desired changes in a biological object (seeds) are possible only with an optimal combination of the values of the biotropic parameters of the acting electromagnetic field. It is rather difficult to determine the optimal parameters of an EMF using conventional methods of agrotechnology and, moreover, to determine the required time intervals, calculated in years. The solution to this problem is the development of a mathematical model, on the basis of which a possible range of changes in the biotropic parameters would be determined, and the optimization of these parameters carried out using special automated systems.

The aim of research is development of an effective informational electromagnetic biotechnology and an electronic system for measuring the chemiluminescence of sunflower seeds to determine the biotropic parameters of the EMF, causing an increase in the yield and quality of sunflower through pre-sowing treatment of its seeds.

2. Methods

A theoretical analysis was conducted to determine the biotropic parameters of the information modulated electromagnetic field for the irradiation of sunflower seeds. To determine the resonance frequency, modulation index and magnitude of the electric field intensity for irradiating sunflower seeds, a model in the form of a spheroid is developed (**Fig. 1**).

As the exciting electromagnetic radiation, let's consider an electromagnetic wave. The excitation wave is characterized by three main parameters: frequency ω, modulation frequency Ω and maximum amplitude E_0. As a result of the interaction of this wave with the dielectric spheroid (model of sunflower seeds), an electromagnetic field is excited in it. The main characteristic of this field is the electric field intensity averaged over the spheroid volume.

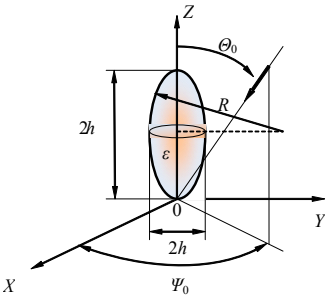

Fig. 1. Electrodynamic model of sunflower seed

Calculations of E_{av}/E_0 (intensity) are performed as a function of the frequency of the exciting wave and the modulation frequency Ω. For the calculations, the following frequency range of the exciting wave 25–40 GHz is chosen. The choice of this range is due to two circumstances. First, the relative dielectric constant $\varepsilon = \varepsilon' - i\varepsilon''$ of sunflower seeds in this range practically does not have frequency dispersion and their real part lies in the interval $3 \le \varepsilon' \le 4$, and the imaginary part is $2 \cdot 10^{-3} \le \varepsilon''/\varepsilon' \le 4 \cdot 10^{-3}$. Secondly, in this frequency range, the wavelength commensurate with the characteristic geometric dimensions of the seeds and, consequently, the intensity of the electric field excited inside the seeds, resonantly depends on the frequency (**Fig. 2**).

On the basis of theoretical studies, it is found that the optimal biotropic parameters of the EMF for the irradiation of sunflower seeds should be determined in the frequency range 35.8...37.8 GHz. In the process of analyzing the model, it was found that for pre-sowing treatment of sunflower seeds, an EMF should be used with the parameters: modulation frequency 100 Hz; modulation index 0.5; intensity of the EF 11.7...13.78 V/m; exposure time 250...350 s.

When choosing a method for measuring the response of bioobjects in the interaction of a magnetic field, it was concluded that photoelectron methods, specifically measuring chemiluminescence, are the most effective.

Currently, the problem of recording light fluxes of low intensity is solved using photometric installations, the main element of which is a photomultiplier tube (PMT).

When chemiluminescence occurs, very weak light fluxes occur, and therefore the intensity of super-weak luminescence when studying the EMF effect on the most important vital processes of biological objects can be estimated using a photomultiplier. Photomultipliers convert the light signal into electrical (electrical impulses). The number of pulses is proportional to

the number of quanta falling on the photocathode. Next, the resulting pulses are amplified and recorded.

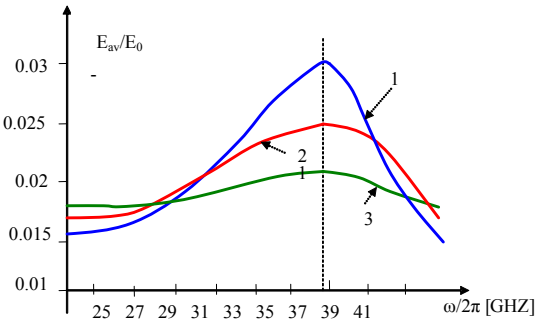

Fig. 2. Dependence of the normalized electric field averaged over the seed volume on the frequency of the exciting electromagnetic wave with the modulation frequency: 1 – Ω=100 Hz; 2 – Ω=50 Hz; 3 – Ω=20 Hz

The functional scheme of the system for changing the chemiluminescence of biological objects using a photomultiplier must include: an EHF generator, a measuring transducer, a recording device, an interface board, a PC, a printing device (**Fig. 3**).

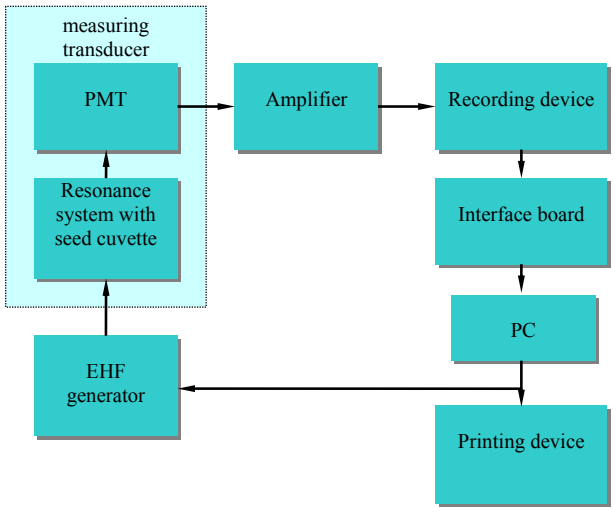

Fig. 3. Functional diagram of changes in the chemiluminescence of seeds

For registration of extremely weak light fluxes of seeds, the photon counting method was chosen, which made it possible to carry out effective measurements of both spontaneous biochemiluminescence and induced information EMF. As a result of theoretical and experimental studies, a system was developed for measuring the chemiluminescence of seeds (**Fig. 4**).

The main elements of the device are: a photodetector, a resonator device with a seed cuvette, an amplifying unit and a high-voltage power supply unit. The signal taken from the PMT anode, for further processing, is fed to an amplifying unit, which includes a preamplifier and an amplitude discriminator. The purpose of the experiment was clarification of the optimal biotropic parameters of the information EMF, which would provide an increase in yield and quality of sunflower seeds when they are irradiated with EMF.

Fig. 4. General view of the device for measuring the chemiluminescence of seeds

4. Results

As a result of theoretical and experimental studies, the biophysical effect of the electromagnetic field of the range on sunflower seeds is substantiated to increase their yield and oil content.

The biotropic parameters of the electromagnetic field, which have a stimulating effect on the seeds, are determined, namely: the resonant frequency, the exposure, the modulation index and the magnitude of the electric field strength.

The method of measuring chemiluminescence is chosen as a method for measuring the response of a biological object. The remaining available methods do not meet the requirements for sensitivity and accuracy of measurements, require the use of more cumbersome and expensive equipment, and photoelectronic methods have the greatest information content, are highly sensitive, and provide real-time information.

Three-year experiments on the pre-sowing treatment of sunflower seeds with the information electromagnetic radiation of the millimeter range show that this technology allows to increase the yield of sunflower by 20...25 %. The analysis for oil content shows that the increase in oil content of sunflower seeds in the experimental plots compared to the control is 10–15 %.

5. Discussion of results

A common disadvantage of all existing technologies, using pre-sowing seed treatment, is the low repeatability of the processing results and the low yield increase – up to 10 %. This can be explained by the imperfection of existing technical tools and research methods, the lack of rapid diagnostic methods, and the lack of sufficiently deep theoretical and experimental studies of the mechanism of action of various physical factors on the seed.

Electromagnetic technology of pre-sowing seed treatment compares favorably with other methods. The use of electromagnetic technology can increase the yield and quality of sunflower seeds, as well as their oil content.

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