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Electromagnetic energy as an impact factor on life processes of a biological object of a plant origin

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Abstract

The foremost problem in the agricultural industry in Ukraine is the issue of improving its energy resources efficiency. The existence of this problem is related to the substantial technological inferiority of the industry to those present in the developed countries, especially in terms of creation of no-waste production technologies of agricultural products. The direct effect on the solving of this issue has the necessity to ensure minimal energy costs during treatment of plant objects. This article presents the research results on the effect of electromagnetic energy on activation of plants development. It was found that each such object has its own individual energy resource and that forceful increase of the latter has specific maximum values and gives rise to the plant development process. At the same time, the implementation of the research results is hindered by some factors, among the most major of which are the following: lack of reliable and complete data on the bioenergy resources of plants, its "natural" chart; unavailability of research on the energy sources interaction processes and its effect on the physiological potential of biological objects, at least at the level of low series, absence of the appropriate electrotechnical equipment, including electromagnetic energy sources.

Keywords: Electromagnetic Energy, Energy Resource, Electromagnetic Energy Dosage, Treatment Exposure, Plants Development and Growth

Major classification: Food Industry, Biotechnology, Environmental Safety and Engineering.

1. Introduction

The foremost problem in the agricultural industry in Ukraine is the issue of improving its energy resources efficiency.

When implementing energy efficient technological processes in the agricultural industry, a significant place holds the issue of improvement of the yield of agricultural crops. The existence of this problem is related to the substantial technological inferiority of the industry to those present in the developed countries, especially in terms of creation of no-waste production technologies of agricultural products. The direct effect on the solving of this issue has the necessity to ensure minimal energy costs during treatment of plant objects.

This problem should be solved by creation of knowledge-intensive technological basis, which in turn may be a

driving force in the improvement of the efficiency of Ukrainian agricultural industry. Development of modern technologies, including energy technology, should provide for significant decrease of energy consumption, development of high-efficiency equipment and technologies for a more profound and qualitative effect on agricultural (plant) products.

The efficiency of application of electrical technologies in agricultural production is defined not only by its ergonomic and economic parameters, but also by activation and stimulation of the effect of electromagnetic fields and electromagnetic radiation, direct current and high and ultra-high frequencies currents, as well as of other energy sources, on biological objects. First of all, it applies to the issues of preplanting treatment of seeds and plants, its disinfection prior to planting and during storage, as well as to protection and nurturing of plants at all stages of crops growing.

Application of electrical technologies in the agricultural industry, which significantly differ to one another by its purpose and end result, require an in-depth study and analysis of qualitative and quantitative impacts on "biological effect" and energy efficiency of different types of energy sources, which in turn requires extensive research involving fundamental knowledge, given that the main research objects are the most sophisticated and, unfortunately, insufficiently researched elements of nature, i.e. living organisms, plants, seeds, etc.

As a matter of fact, the use of electromagnetic energy as a method for increasing germinating energy of various plants and its herbage has been already in practise since XVII - XVIII centuries.

Thus, for example, a positive effect of electricity on germinating period of flowers and seedlings of different vegetables, was recorded in France (by Abbot Nollet in 1748, and by Abbot Bertolon in 1780), who, unfortunately, were unable to explain the results of their experiments. Similar results were obtained by flower enthusiasts Emperor Napoleon, Benjamin Franklin, the president of the USA, and others. The impact of negative electric charge on activation of biological objects was found in the 30s of XX century by famous Russian biophysicist A. Chizhevsky, who was the first person to explain this phenomenon, and who highlighted the efficiency of the effect of negative charged electricity on a biological object.

Today we may assert with a sufficient certainty that electromagnetic energy as an energy source has an effect in changing energy resources of plants, which has a substantial effect on the plants development and growing processes.

2. Problem

Application of electrical technologiesin the recent years has been extensively studied by scientists of many countries in Western Europe, the USA, Japan, Russia, and other countries. Increased interest to electrical technologies in those countries is evidenced by an increase in annual investments into the research, for example, in the USA from 8 to 35 million USD, and by increasing number of electrical technology equipment, in Japan its number grew by 43%, in Russia by 21%, and by its "versatile capabilities", which "have never been in doubt, even when various problems arose in the process of implementation of these technologies".

The analysis of the development of electrical technologies demonstrates an increase in the recent times (end of the XX century – the beginning of the XXI century) of interest in practical implementation of electrical technologies in agricultural industry and primarily towards an increase of production and improving the quality of plant products.

The research performed during the past few dozen years confirms that high economic feasibility and cost-effectiveness of electric technologies (according to the projected estimates of the leading scientists of various countries around the world made for the period 2000-2030), shall facilitate, especially in agricultural industry, development of new highly efficient technologies, and primarily in crop farming, which will be aimed at biological stimulation of vital activity of plant products and as a result thereof – an increase of its yield. First of all, it applies to the issues of preplanting treatment of seeds and plants, to protection and nurturing of plants at all stages of crops growing.

As it is evidenced by findings of studies conducted in the recent years, in order to solve the problem, we should consider it from the standpoint of application of electrical energy not only as an energy source for electrification and automation of technological processes, but also as a direct participant effecting the agricultural products with a purpose of influencing their structure, biophysical properties, quality and yields of the end products.

A great number of scientists both in Ukraine and abroad have been studying the effects of impact of electrical technology methods and means on biological objects (soils, seeds, seed materials, plants). Among the Ukrainian scientists, we should highlight the works of Bereka (1996). Inozemtsev and Mishchenko (2016), and Chervinskyi (2018).

They have studied the issues of the effect of electromagnetic fields, electromagnetic radiation, electric ozonation, and other types of energy on biological objects of plant origin in the processes of preplanting treatment of seeds and

seedlings, its effect on growing and storage of crops primarily in the part of its sowing qualities, homogeneity and increase of yields of agricultural crops, as well as in terms of quality and term of storage of obtained products.

The analysis of the research demonstrates that in some cases the use of electrical technologies cannot be replaced by other methods. For example, in processes related to stimulation of crops growth, forming of resistant to stress factors seedlings, transfer of grading factors from generation to generation, targeted effect on physiological and biological processes in the seed materials, and improving the yield of cultivated crop growing.

Multiple studies on the application of electrical technologies in crops growing, regardless of the electromagnetic source, demonstrate indisputable advantages of the impact of the latter on the processes of stimulation of seed germination and rehabilitation of plants of agricultural crops, acceleration of plant development during the growing period, improvement of sowing and yielding characteristics of seeds, as well as resistance to pests, microorganisms and climate conditions. The obtained results prove the possibility to effect the vital activity of biological objects by rehabilitating its bioenergy potential. Thus, a direct effect of energy sources on the changes of inner energy of an energy field (biofield) of a biological object causes substantial changes to its development, exit from the state of quiescence and activation of the so-called dynamic (transport) functions, which are embedded by the nature itself on the genetic level, i.e. germination energy, homogeneity, survival capability.

Research objective – analysis of the effect of electromagnetic energy on activation of plants development.

3. Materials and Methods

Obtained tangible results in regard to efficiency of application of electrical technologies in crops growing demonstrate with a great deal of certainty the possibility of existence of, in our opinion, a hypothesis on the key role of the energy as a factor of changes to the algorithm of vital activity of biological objects, which is basically what crop products are.

The studies performed by scientists from Belgium, Canada, Germany, Russia, the USA, as well as from Ukraine, prove the possibility of activation of metabolic processes in vital activity of biological objects by influencing its biological processes through additional energy.

An excellent example of the recognition of the possibilities and prospects of application of electrical technologies (electromagnetic energy) in terms of improving yields of agricultural crops by creating plants that are resistant to pests, various microorganisms, development of cultivated plants varieties with improved heritage features, etc., are the high rates of growth of investments in this area of study in a number of developed countries around the world.

The long-term effect and relevance of such solutions is proven by the results of numerous studies on the application of electrical technologies in crops growing aimed at improving homogeneity and yields of different grain crops (wheat, barley, corn) and vegetable crops (cucumbers, tomatoes, carrots, pepper, eggplants) to 15 … 20 % and 12 … 18 % respectively.

Accumulated by scientists of different countries experience provides grounds to assert with a sufficiently high certainty the existence in living organisms, seeds, plants, of its own development programme which is recorded by the nature itself in their genes.

This being said, an important factor is the necessity of unlocking of the genetic and physiological potential of plants, which in turn requires the conducting of a research on the intersection of two disciplines, namely electrical technology and biophysics, which will establish the key role of the electromagnetic energy in the vital activity of biological objects (plants) and provide additional information on possible ways to increase yields of agricultural crops.

The appropriateness of existence of such hypothesis does not contradict the objective reality and has a number of factual confirmations in the form of significant impact on genetic and physiological potential of biological objects.

Activation of vital activity processes is achieved as a result of redistribution and disrupting the balance of energies in biological objects, as well as by activation of transportation of energy in them by improving permeability of cell membranes.

Implementation of electrical technologies in the agriculture industry and especially in crops growing requires conducting of a research on a qualitatively new level, that is, on the level of study of energy exchange processes in objects of plant origin. The studies conducted at the end of the XX century and at the beginning of the XXI century, confirm that plants have a “natural instructions”, i.e. the process of their development is dictated by a specific situation, which in turn enables the creation of modern technologies which will facilitate more efficient use of electrical energy, and the most importantly – will improve yields of agricultural products.

At the same time, the lack of information and objective assessment of the reaction of biological objects to the direct effect of energy sources requires more in-depth and specific theoretical evaluation from the standpoint of

complete understanding of the impact mechanisms and transformation of the received energy by living organisms, plants, seeds, which are the most perfect nature elements.

Additionally, still left without an answer are the issues on the procedure of absorption by plants of the transferred energy, absence of differentiation of its dosage, the impact of the exposure and inner energy on the field germination of seeds, forming of the elements of crops yield structure, dependency of the energy exchange processes on the varietal and species particular characteristics of agricultural crops, its biological features, metrological conditions of the growing period, the survival capabilities of plants.

The lack of answers to those questions does to a great extent hinder the implementation of the electrical technologies in crops growing and it creates a necessity for conducting experimental and analytical studies on a qualitatively new level, that is, on the level of understanding of energy exchange processes in objects of plant origin directly in living plant cells.

4. Results and Discussion

The analysis of the state of the problem and accumulated by us extensive experimental and practical materials conclusively suggest promising prospects and substantial advantages of the application of electrical technology methods and especially in part of the effect on physiological and biological processes, primarily on stimulation and activation of plants growth, their rehabilitation, which is achieved through the treatment of a biological object with different types of electromagnetic energy(Grigorev, 2002).

The research performed by us in the recent years in regard to obtainment of information on the role and effect of electromagnetic energy on the energy exchange processes in the objects of plant origin confirm the key role of energy in activation of vital activity in plant objects.

This effect primarily manifests in stimulation of germination of seeds through electromagnetic energy during the preplanting treatment period, growing period, etc.

Our research found that the process of plants development is largely defined by the germination energy, which has its specific parameters for each biological object. This is also confirmed by studies conducted by scientists from Belgium, the Netherlands, Russia, the USA, Japan, who study activation of vital activity of various biological objects (seeds, seedlings, etc.) through application of electromagnetic energy.

The research performed by us has established a direct connection of the amount of energy and its dosage with inner energy of crops, which is embedded in them by the nature itself.

Thus, for example, we have found that the so-called “heliophyte” plants require less additional energy than others do. This may be explained by the energy resource embedded in them on a genetic level.

The appropriateness of existence of such assumption was proven by a number of experimental evidence, and in our opinion, it does not contradict the existing understanding of biological objects’ reactions to the effect of different energy sources.

Results obtained by us demonstrate that treated batches of biological objects obtain the maximum rate of germination, growing or rehabilitation at different doses of electromagnetic energy, which is calculated according to the formula below (Chervinsky, Usenko, & Spodoba, 2019; Inozemtsev, 2013):

$$, \text{J/m}^3, \quad (1)$$

where K_n is a coefficient which is contingent on the absorption of electromagnetic energy by different biological objects (K_n = 0.6 – 0.9); E is a flow of electromagnetic energy, W/m^2; S is the area of a treated object (seeds); m^2; t is the time of treatment, s; V is the volume of treatment, m^3.

Thus, for example, the dynamic pattern of the change of length of sprouts of different crops (wheat, barley) and seeds of vegetable crops (tomatoes, cucumbers, carrots) in relation to the dosage of electromagnetic energy is illustrated on Fig. 1. It is also worth noting that an increase of herbage of plants was also observed.

By analysing the dependencies on Fig. 1 we may assert that for each plant its length is determined by the dosage of electromagnetic energy, exceeding of which basically leads to a death of a plant or to a deceleration of its growth. Thus, upon treatment of seeds of grain crops (wheat, corn) and vegetable crops (tomatoes, cucumbers) in the field of corona discharge, an increase in the rate of germination was achieved up to 12 – 15 %, and in some cases, up to 22 – 24 % (curves 1, 2) was observed at the electric-field intensity of (E = 2 ... 5 kV/cm) and the dosage rate of ($Д$ = 3 ... 6 J/cm^3). Increase of those parameters (E = 5 ... 6 kV/cm, Д = 6 J/cm^3) on the contrary decelerated the germination process and led to a death of seeds (curves 4, 5).

Similar results were observed upon treatment of seeds of barley and coniferous species.

It is also worth noting the results obtained after the treatment of pea seeds (Fig. 2), where increase of the dosage reduced almost twofold the germination rate up to 70%.

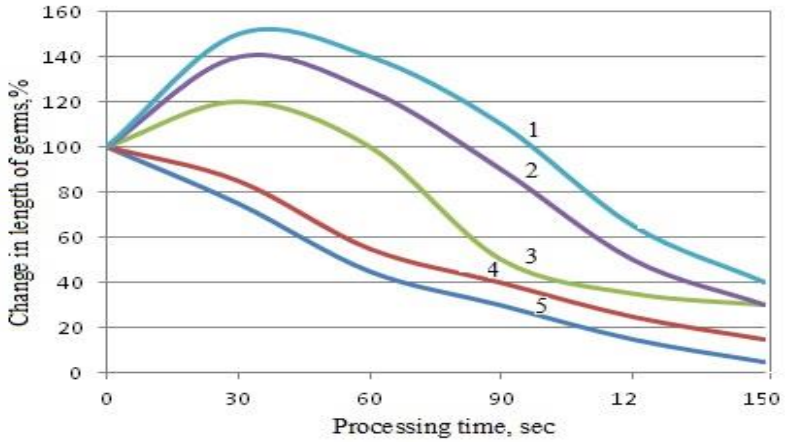

Figure 1: Change of the length of sprouts of different crops in relation to the dosage of electromagnetic energy (treatment in the electric field of corona discharge whereby E = 2.0 … 2.5 kV/cm and exposure *t* = 10 … 150 s): 1 – tomato, dosage – 5.3 J/cm^3; 2 – tomato, dosage– 3.6 J/cm^3; 3 – tomato, dosage – 2.4 J/cm^3; 4 – tomato, dosage – 8.1 J/cm^3

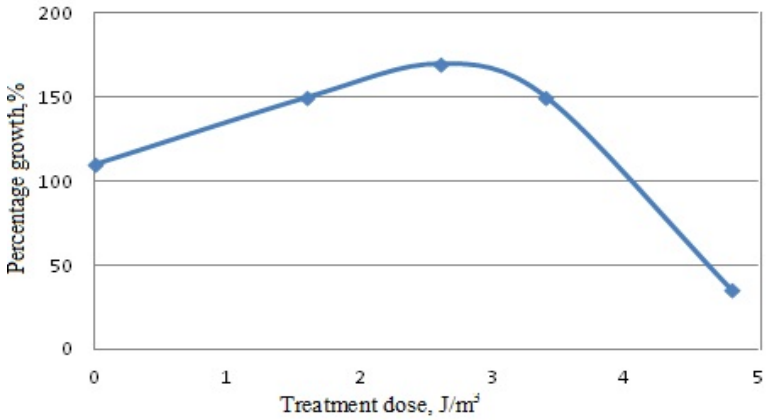

Figure 2: Change in seeds growth based on energy (treatment dosage)

We also conducted research on the effect electromagnetic energy has on biological object during a plant rehabilitation period, i.e. during the period of harvesting and before putting into a long-term storage, aimed at prolongation of the term of storage and improvement of its preservation capacity. This research was based on a set of conditions, which to a substantial degree, ensured the required quality of the products at the end of storage. We took into consideration a great number of factors which have effect on loss of quality and weight: technological (*E*, *L*, *Q*, t_{mp}, *I* and other), biological (composition, type and quality of products, oxygen level at the storage facility, gas composition of the air, its humidity, temperature, etc.).

The results obtained by us (Fig. 3) after the treatment of carrots and potatoes demonstrated that an object, which was in the treatment zone with the highest electric-field intensity and was under the strongest effect of the field, suffered the lowest weight losses during the long-term storage (approximately 10-15%) and retained the best quality in comparison with (curve 3) other treated objects (curves 1, 2; the losses of which at the end of storage were in the range of 15-25%) and reference samples (curve K, losses approximated to 35-45%).

It reaffirms the above results of the research, i.e. that the important factor of electromagnetic energy influence on a biological object is the dosage of received energy.

The data provided herein proves the existence of a hypothesis on the dependency of a biological object's state on the amount of received energy at various periods of time (Chervinsky, 2018).

This dependency of growth of each plant on the dosage of electromagnetic energy may constitute a model which should take into account the plant's natural energy and its energy resource, which in turn determines its capacity to growth as a result of additional treatment by different types of electromagnetic energy. Furthermore, the amount of

energy and treatment dosage must take into account the natural energy resource embedded in a plant and necessary additional value, which actually will activate and stimulate or decelerate the plant's growth process depending on a growth period of an object.

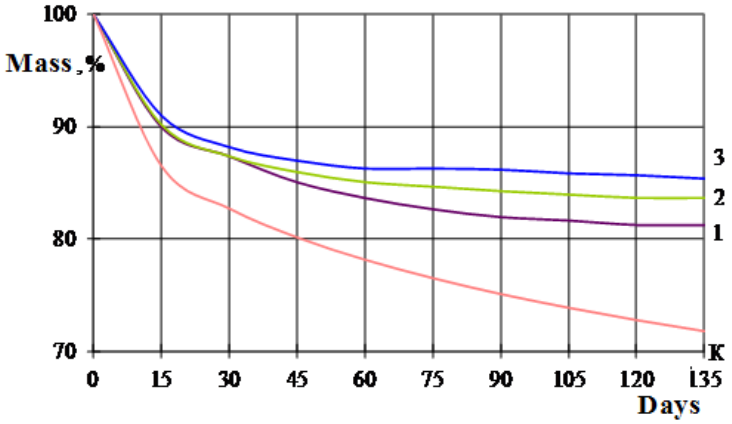

Figure 3: Carrot weight loss during aero-ionization treatment at different electric field strengths

1 – in accordance 1,5 kV/sm; 2 – in accordance 2,0 kV/sm; 3 – in accordance 2,5 kV/sm; K – control

In our opinion, it is possible to apply the following approach, which is based on a dependency of energy on the quantity and the character of plant substance (*M*). This dependency shall have the following form: *M=f(t)*, where the growth rate is:

, (2)

where P_E is an energy resource of a particular plant.

In such a case the dependency (Fig. 4) of growth of plant substance shall depend on its energy resource, which constitutes a natural germination energy (P_o) and additional energy (P) which a plant can receive at a maximum level in order to intensify its growth and setting the maximum time of treatment (t_{max}) with the application of electrical energy.

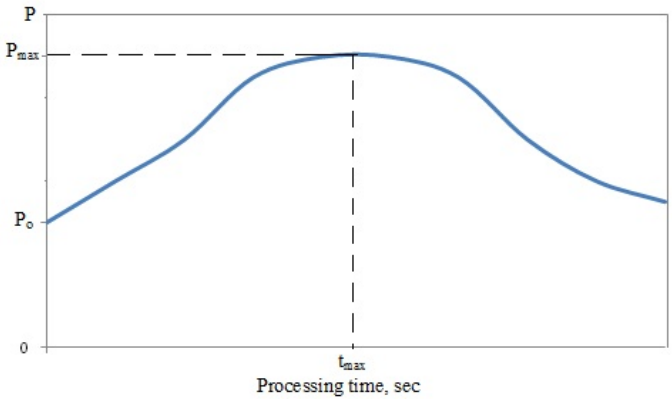

Figure 4: Dependency of energy resource of a biological object on time

However, notwithstanding the substantial significance of the results we have obtained (improved yields of grain and vegetable crops up to 9-15% and 10-24% respectively, and in a number of cases to more than 20%), they did not find any practical use in the most cases.

The situation studied by us that is present in regard to the progressing the promotion of such electrical technologies from the field of scientific and experimental research to their practical implementation, allowed us to determine the directions and reasons which hinder such implementation.

The authors of this research believe that the main reasons are the following:

5. ambiguity of the level of developed products, conducting of experimental research without objective substantiation of the selection of treatment procedures (significant diversity in treatment parameters), their optimization, involvement of different energy sources without taking into account their "manufacturability", the complexity of transfer of energy to the treatment objects, the costs and specifics of maintenance of technical equipment;

6. lack of uniformity of opinions in understanding of the mechanisms and assessment of the stimulating effect of the energy on the processes of change and redistribution of inner energy balance in objects of plant origin, which is attributable to a great extent to the absence of objective methods for measurement in numerical values of energy resources and the germination energy value;

7. the necessity of application of differentiating approach when selecting technological treatment procedures taking into account individual biophysical and physiological features of objects of plant origin;

8. absence of manufacture of equipment, even in small batches, including high-efficiency energy sources, which are the main element of electrical technology equipment, which could meet the requirements of the technological treatment processes of objects of plant origin.

Some complications also stem from misperception by the professionals in the agriculture industry of the application of such electrical technologies for activation of the vital activity processes of plants.

Certainly, the above reasons are not exhaustive and do not include other reasons, but in the opinion of the authors of this research, they are the primary causes that hinder the transfer of this problem into a practical field.

9. Conclusions

Our research proves the efficiency of electromagnetic treatment of seeds and seedlings of various objects of plant origin. Concurrently, it was found that each plant has its own individual energy resource and that forceful increase of the latter has specific maximum values and gives rise to the plant development process.

As of today, its implementation in manufacturing environment is hindered by the lack of information on the behaviour and processes of quantitative and qualitative changes in plants when applying electromagnetic effect on them.

The implementation of the research results is hindered by some factors, among the most major of which are the following: lack of reliable and complete data on the bioenergy resources of plants, its "natural" chart; unavailability of research on the energy sources interaction processes and its effect on the physiological potential of biological objects, at least at the level of low amounts, absence of the appropriate electrotechnical equipment, including electromagnetic energy sources.

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