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THE INFLUENCE OF PULSED LOWFREQUENCY ELECTROMAGNETIC FIELD ON WHEAT SEEDS

Abstract
The article investigates the influence of low-intensity pulsed radiation electromagnetic fields on the cell structure of spring wheat seeds. The study reveals that exposure to this electromagnetic field prior to sowing in a controlled laboratory setting significantly enhances various growth parameters. Specifically, it increases the germination rate and overall germination success, as well as the mass of both sprouts and roots when compared to a control group that did not receive the treatment.

Data collected through optical microscopy from sections of both irradiated and unirradiated seeds, alongside results from differential scanning calorimetry, illustrate that the application of the electromagnetic field induces notable changes in cellular structure. Additionally, alterations in the mineral composition within the grains are observed, leading to the formation of associates and unique crystal structures of starches. These modifications enhance the rate of water diffusion through cell membranes, thereby accelerating seed germination and promoting more robust plant growth. This research underscores the potential of using electromagnetic fields as a beneficial tool in agricultural practices.

Keywords: *electromagnetic field of pulsed low-frequency radiation, irradiation mode, grain structure, optical microscopy*

Introduction

To date, among the scientific community and specialists of agriculture there is no consensus on the effectiveness of the treatment of biological systems by different types of electromagnetic radiation [1-4]. These facts prevent the introduction of physical stimulation of seeds of agricultural crops in industrial technology.

The ambiguity of the results of plant growth stimulation is associated with many factors that determine the nature of the impact of electromagnetic radiation. The main among them are: the nature of the biological object of influence, the type of source of energy impact, technological parameters of impact. Of great importance is the high sensitivity of plant cells to frequency characteristics, intensity, radiation dose, exposure time [8]. The quantum of light incident on plants, the energy received and processed by them, vary depending on the wavelength of radiation and depend on the cellular composition and structure [5-7]. At the same time, depending on whether the electromagnetic field is constant, variable, pulse, etc., the mechanism of energy perception and its transmission to the entire plant body can change. These factors determine the changes in the biochemical photochemical and oxidative processes occurring in the plant, forming the basis of life. Currently, there are no systematic studies devoted to the analysis of the mechanism of influence of pulse fields on the life of plants.

The aim of the work is to study the features of the effect of a pulsed traveling magnetic field on the structure and properties of grains and to establish a connection between these parameters and the growth rate of wheat seeds.

Experimental studies were carried out on the seeds of spring wheat varieties “Omskaya- 18” (harvest 2016 Open Company “Ulanskaya MTS”, East Kazakhstan). Seed treatment was carried out by a traveling pulsed magnetic field using a magnetic therapy device ALMAG -01.

Seed sowing parameters were determined in accordance with GOST 12038-84. Germination energy was determined on the fifth day, germination – on the 8th day after sowing. Morphophysiological parameters of seedlings: plant mass, germ and root were determined for 10 days.

Experimental data were processed with the help of dispersion and correlation analysis according to the program “AGROS -2.02”.

The structural organization of the grains, the morphology of the inner part of the grain was determined using a polarization optical microscope Axio Imager Z2m, Carl Zeiss with software Axio Vision (manufactured by CarlZeiss). at 50×, 200×, 500× magnification in transmitted and reflected light. Longitudinal sections with a thickness of ~1, 3, 5 mm were analyzed.

The method of differential scanning calorimetry studied thermophysical properties of the initial and irradiated grains, obtained curves of thermograms of water evaporation and thermal degradation of carbohydrate-containing products. Thermograms were obtained on the DSC device (model DSC-204 F1 of Netzsch, Germany) at a heating rate of 10 deg/min in the temperature range 30-300°C in the argon current. To accurately determine the temperature of the characteristic peaks used standard-indium (melting point T_m = 156,7°C). The accuracy of temperature parameters of DSC was ±2^{o}C.

To establish the diffusion parameters of water through cell membranes of grains obtained kinetic curves of seed swelling in distilled water at a temperature of 22° C. Tests were carried out on samples containing from 10 to 50 seeds for 10 repetitions of each. Dry samples of seeds were placed in vessels with distilled water. At 1 cm^2 of the sample surface had at least 100 cm^3 of liquid. The liquid with the seeds placed in it was mixed by rotating the vessel. After that, the samples were removed from the vessels and placed on a clean filter and removed moisture from the surface. Then weighed on electronic scales. The degree of water absorption was calculated by the formula:

$$\alpha_\tau = \lfloor (m_\tau - m_o)/m_o \rfloor . 100\% \qquad (1)$$

where m_o is the initial mass of the sample, m□ is the mass of the sample after saturation with water during α_τ . The time intervals were 15 to 30 minutes. For the maximum degree of swelling of seeds, the mass of the sample reached before the appearance of the germ seedling was taken. When determining the maximum degree of swelling in the water, the equilibrium was considered to be achieved if the difference between the mass of the seed samples did not exceed 1% . The standard deviations of the experimental values of the diffusion parameters were within 10%.

Methods and materials

Spring wheat seeds ("Omskaya-18") were treated using a pulsed low-frequency electromagnetic field generated by the ALMAG-01 device (6 mT, 16 Hz) for 3, 6, 9, and 20 minutes. Germination energy and seedling growth parameters were assessed in laboratory conditions according to GOST 12038-84. Structural changes were analyzed using optical microscopy (Axio Imager Z2m, Carl Zeiss). Thermal properties were studied by differential scanning calorimetry (DSC-204 F1, Netzsch). Water diffusion kinetics were evaluated via seed swelling tests, and data were analyzed using dispersion and correlation analysis (AGROS-2.02 software).

Analysis of the mineral content in wheat seeds showed that irradiation of seeds for 9 minutes did not change the content of various groups of compounds. The water content is 11-11.2%, protein is 14.9-15%, starch is 66-68%, gluten is 36-38%. The amount of dispersion in determining the content of substances is ±2% [11]. It is obvious that the change in the position of the peaks on the thermogram of destruction is due not to a change in the content of functional groups in the grains, but to a change in the structure of the minerals contained in the seed. With regard to the problem of increasing the shelf life of grain, a particularly important issue is the question of the structural features of water in irradiated seeds. To answer this question, it is necessary to establish the nature of the change in the process of moisture evaporation under the influence of EMF. The evaporation mechanism was studied using the process parameters, such as activation energies and preexponents of hydrogen bond decay in vapors [7]. For this purpose, a thermogenetic analysis of the exothermic evaporation peak obtained in a non-isothermal mode at a constant heating rate of a grain sample equal to 16 degrees/min was used.

Description of the design of the ALMAG-02 device. The device consists of a power supply and control unit and three types of radiators.The main radiator contains a flexible radiating surface consisting of 4 flexible radiating lines with 4 inductors each. The radiator in the form of a separate flexible radiating ruler contains 6 inductors. The local radiator contains two inductors. The design of the radiators in the form of a flexible radiating surface and a flexible radiating ruler allows them to be wrapped around the working body of the transported grain material or deployed when exposed to a fixed grain layer. A local radiator in the form of a "washer" provides only a local, concentrated effect. The pulsed magnetic field generated by a local radiator has a greater penetration depth than the field generated by other radiators. The following controls and indications are located on the control panel of the power supply and control unit (Fig.1):

Figure 1. Magnetic therapy device "ALMAG - 02"

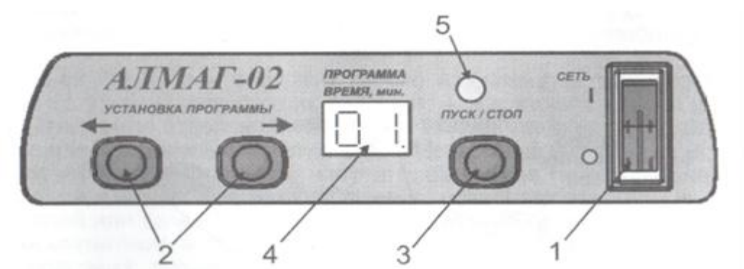


Figure 2 – Controls and indications

1 - Power switch; 2 – buttons "←" "→" - setting the program number (in the direction of decreasing / increasing the number); 3 – button "START /STOP" - turning on /off the magnetic therapeutic effect; 4 – LED indicator, which, depending on the operating mode, displays either the program number or the exposure time according to the selected program, or a fault code; 5 is an indicator of the magnetic therapeutic effect.

The device allows you to change the programs that determine the modes of grain irradiation. Three main programs were implemented. No. 7, No. 22 (B= 6 mTs, f=3 Hz) and No. 23 (B=6 mTs, f=16 Hz). The device provides the formation of continuous and intermittent pulsed magnetic fields (traveling, stationary), differing in configuration, intensity, direction and speed of movement of the magnetic field in space. The ability to simultaneously affect relatively large areas and combine planar effects with local ones increases the effectiveness of the device. The device has a simple, intuitive user interface (just two buttons to select the program number and a button to start the program).

Results and Discussions

Treatment of wheat seeds was carried out by a pulsed traveling magnetic field with a pulse frequency of 16 Hz and an amplitude of magnetic induction of 6 MT at a duration of exposure of 3, 6, 9 and 20 minutes. Before sowing, the irradiated seeds were stored for two weeks to achieve their equilibrium state. In the laboratory, irradiated and unirradiated (control) seeds were germinated in vessels filled with moist sand. The number of seeds in the sample was 50 pieces, repeat - four times. Their energy of germination and germination, biometric indices of morphological organs of seedlings, weight of stems, leaves and root system were determined.

The data obtained are presented in tables 1 and 2. As can be seen from the table.1. the treatment of seeds leads to increasing the germination energy and germination of seeds of even short exposure to the air. And as the optimal mode of irradiation should be considered - 9 minutes. The same data are derived from a table.2. It should be noted the tendency to the greatest influence of the magnetic field in relation to the development of the root system.

Table 1 - Germination energy and germination of spring wheat seeds, varieties "Omskaya-18", exposed to electromagnetic pulse low-intensity magnetic field (6 mT, 16 Hz)

Measurable characteristic	Control	Magnetization time, min.		
		6	9	20
The energy of germination of seeds, average values for three parties', %	70.0 78.3 75.7	80.0 88.0 83.0	90.0 91.0 83.0	86.0 89.0 86.0
Seed germination, average values for three batches, %	77.0 79.3 77.7	89.0 91.0 86.0	89.0 92.0 86.0	92.0 92.0 89.0
Deviation from control, %				
For seed germination energy	- - -	14.3 12.4 9.6	28.5 16.2 9.6	22.9 13.7 13.6
For germination	- - -	15.6 14.8 10.7	15.6 16.0 10.7	19.5 16.0 14.5

Table 2. Morphophysiological parameters of spring wheat seedlings, varieties "Omsk-18»,exposed to electromagnetic traveling pulse low-intensity MP (6 mT, 16 Hz)

Measurable characteristic	Control*	Magnetization time, min.			
		3	6	9	20
The mass of the plants, g	0.078±0.01	0.081±0.01	0.091±0.01	0.096±0.01	0.09±0.01
The mass of the seedling, g	0.053±0.01	0.056±0.01	0.062±0.01	0.074±0.01	0.059±0.01
The mass of the root, g	0.020±0.01	0.021±0.01	0.025±0.01	0.023±0.01	0.030±0.01
Deviation from control, %					
For the mass of the plants	-	3.4÷3.8	16.7÷25.0	20.4÷55.9	13.6÷47.0
For the mass of the seedling	-	4.7÷7.0	14.3÷67.4	33.3÷95.3	9.5÷60.5
For the mass of the root	-	4.5÷63.1	25.0÷84.2	15.0÷73.7	50.0÷110.0

* Control experience. The given data are obtained for 100 seeds

Comparison of micrographs of slices of irradiated and control grains obtained with an optical microscope (Fig. 1a,b) shows a change in the cell morphology of seeds under the action of a magnetic field.

A noticeable change is found in the structure of mineral substance included in the cell structure of seeds (Fig.2 a,b). If a mass of small white crystals is observed in the control sample (Fig. 2 a), apparently, from starch grains, in the sample treated by a magnetic field, the size of these grains increases markedly (Fig. 2b). In this case, instead of an even mass of starch crystals covering the endosperm of the grain, there are areas containing clearly enlarged crystal formations - associates (Fig.3).

The presence of rearrangements in the structure of mineral substance of irradiated seeds is confirmed by changes in their thermal properties compared to the control ones. Thermograms

of differential scanning calorimetry (DSC) of control and field-treated seed samples were obtained. As shown in Fig.4, thermograms of each of the samples contain exothermic peak of water evaporation and endothermic peak of thermal decomposition of carbohydrates.

When comparing the control and irradiated grains, it can be seen that their thermograms differ markedly. On the thermograms of magnetized samples first exothermic peak is strongly shifted into high temperature region in comparison with the control sample. The shape of the endothermic peak changes. Its intensity decreases with a strong broadening towards high temperatures, and the more, the more processing time (Fig.4). It is important to note that the change in the shape of endothermic peaks occurs without a noticeable change in the heat of the process. The observed character of changes in thermograms for samples treated with a magnetic field means an increase in the heat resistance of grains, which can be explained by the formation of associated carbohydrate structures in the grain. This is also indicated by the shift of the exotherm of water evaporation to the high-temperature region, which means the transition of water molecules from the free state to the associative one.

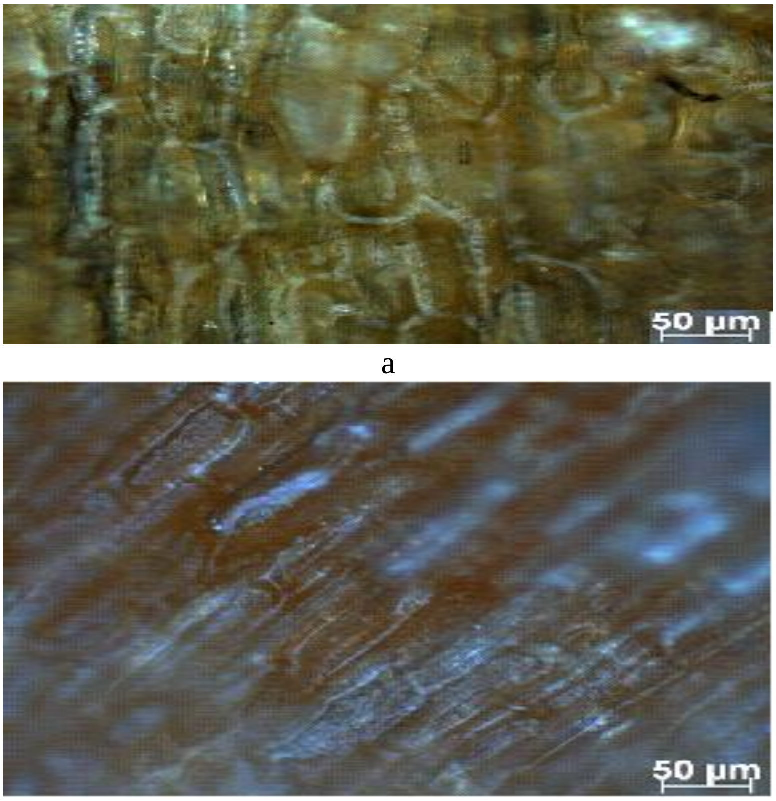
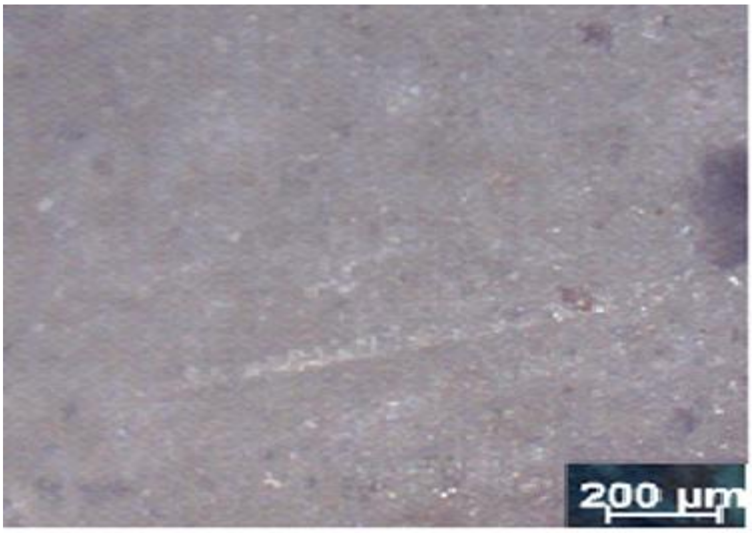
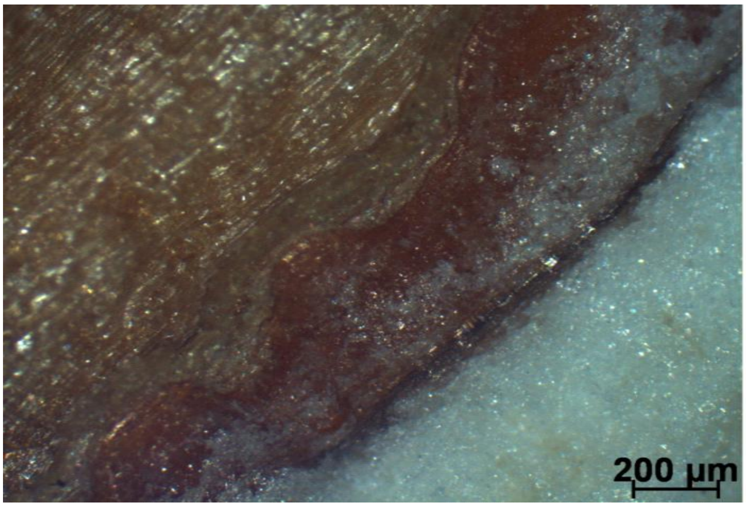


Figure 3 - Micrographs of cell structure of spring wheat grains before (a) and after (b) exposure to LF EMR



a



b

Figure 4 - Micrographs of the longitudinal seed cut surface for the reference sample (a) and for the magnetized seed (b)

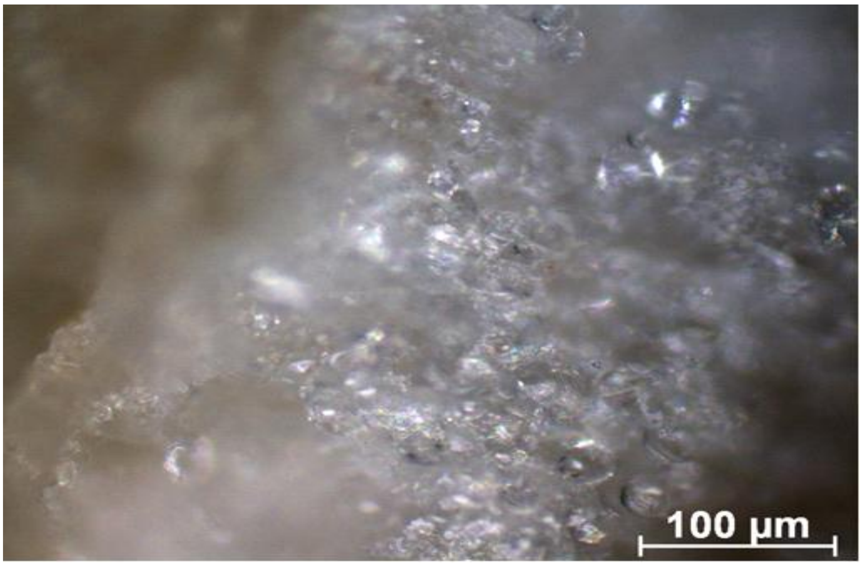


Figure 5 - Micrograph of starch grains in the magnetized grain, localized in the endosperm

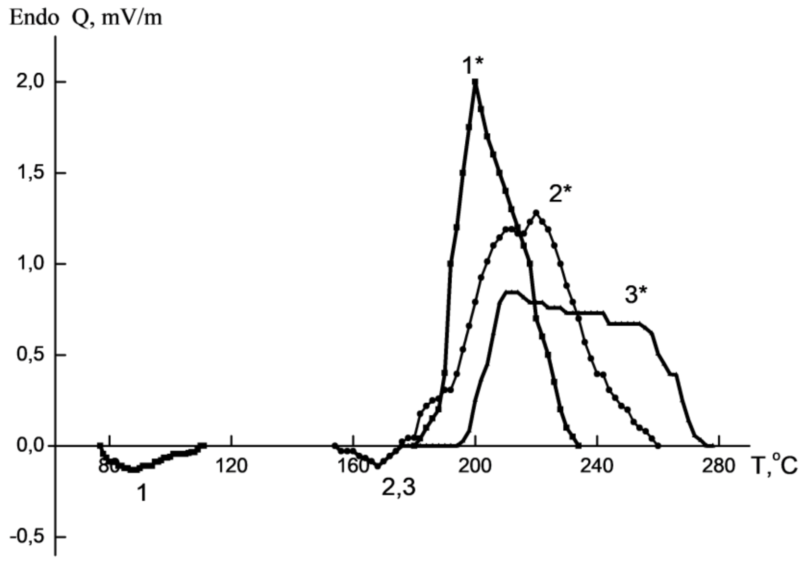


Figure 6 - Thermograms of water evaporation (1,2,3) and thermal degradation of carbohydrate-containing components (1*,2*,3*) initial control (1,1*) and irradiated for 9 (2,2*) and 20 (3,3*) min seed samples.

The data obtained do not contradict the literature. It is known [9] that the action of the electromagnetic field (EMF) is directed to the macromolecules of starches, proteins included in cell structures. In a living cell all biomacromolecules are present in solvated form (covered with a shell of water molecules). A significant role of water in magneto biological effects is known [10]. Exposure to EMF can lead to the formation of starch associates and alter the structure of the solvate shell of biopolymers localized in cells, and as a result, can change their functional activity [11].

On the other hand, according to the data of [11] at external exposure to EMF with low amplitude and frequency close to the natural frequency of damped oscillations of the cell membrane, a resonant response is observed in the system, which can lead to a change in its permeability. Changes in membrane permeability should lead to changes in seed swelling in the aquatic environment due to changes in the diffusion of water from the environment through the endosperm to the embryo.

The work studied the kinetics of swelling of seeds. The swelling curves of the studied samples have a typical form of the process with an accelerated initial stage and a stationary site. The kinetics of swelling in water is described by the equation [7]:

$$\frac{dx}{d\tau} = \mathrm{k}\,(\alpha_{max} - \alpha_{\tau}) \qquad (2)$$

$$k = \frac{1}{\tau} ln \frac{\alpha_{max}}{\alpha_{max} - \alpha_{\tau}} \qquad (3)$$

where k is the constant of the swelling rate

α_{τ} - degree of swelling by time;

$_{max}$ – maximum degree of swelling,

Equations (1,2) were used to determine the values of water diffusion coefficients through the mineral component of the grain. The data obtained are presented in table. 3. As can be seen from the table, the irradiated samples have smaller water diffusion coefficients, respectively, higher process speed.

Table 3 - Swelling of wheat seeds in distilled water at 22°C

Sample	Magnetization time, min.	The value of the maximum degree of swelling, $_{max}$	The value of the rate constant for diffusion of water, k, h^{-1}
spring wheat	0	0.37±0.03	0.190±0.02
spring wheat	3	0.50±0.03	0.295±0.02
spring wheat	6	0.49±0.03	0.363±0.02
spring wheat	9	0.47±0.03	0.383±0.02
spring wheat	20	0.61±0.03	0.340±0.02

It is important to note that the change in the water diffusion coefficient correlates with data that indicate the restructuring of the starch component in the irradiated grains. The maximum degree of seed swelling correlates with the increase in the time of their treatment by the pulse field, the diffusion coefficient correlates with the data on the values of seed germination and germination energy.

Conclusion

It is known that the effect of low-intensity pulse electromagnetic field on the cellular structure of biological systems is due to dissipative resonance - the phenomenon of increasing the amplitude of oscillations due to the ordering of the system structure under the periodic action of weak external forces. The ability of biological objects to maintain the homeostasis of the internal environment under changing external conditions, as well as adequately respond to external signals, is largely due to the functioning of cooperative systems with threshold response. According to the mathematical model, the behavior of the cooperative system can change significantly as a result of minimal changes in the number of activated molecules [7]. As a result of the weak external influence is enough to cause the system state switching. If we consider the effect of weak EMF on the cell within the framework of the hypothesis of dissipative resonance, we can assume that the impulse, periodic (frequency) effect of low-frequency EMF causes synchronous rearrangements of many protein channels, which can lead to a synergistic effect with the formation of complex associated structures in the membrane, and as a result to an increase in its permeability. This hypothesis is confirmed by the results obtained in the work. Thus, under the influence of the magnetic field on the cell inside the seed, the diffusion of water molecules from the external environment is accelerated, as a result, the rate of initial chemical reactions in the cells of these seeds increases. Water entering the grain from the external environment takes part in the chemical reaction of hydrolysis of carbohydrates in the endosperm, initiating the development of the embryo. As a result, a short-term impact of the pulse field on wheat seeds is enough to achieve high efficiency in relation to the rate of their germination and development.

Thus, the biological effect achieved by the action of a pulsed magnetic field on wheat seeds is due to the change in the structure of starch in the cell, the increase in the permeability of cell membranes. As a result, the diffusion of water to the embryo is accelerated, increasing the enzymatic activity that triggers the growth processes in the cell. This leads to the acceleration of germination of the embryo and the formation of the root system.

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References

[1] *Andreichuk V. K., Rednev A. E., Potapenko I. A.* “Electrophysical methods of pre-sowing treatment of seeds of different crops”//Application of electrical devices in agriculture. Scientific works of KGAU. 2020. Issue. 381 (409). P. 74-78. https://nasu-periodicals.org.ua/index.php/science/article/view/7613

[2] Alchimbayeva , A., Shibryaeva , L., Chaplygin , M., Zhumagulov , Z., Zhetpeisov , M., & Sarkynov, Y. (2025). HEAT RESISTANCE OF WHEAT SEEDS TREATED WITH LF EMP. *Izdenister Natigeler*, (2 (106), 566–576. https://doi.org/10.37884/2-2025/56

[3] *Erokhin A I.* “Application of Electromagnetic Fields for Pre-sowing Seed Treatment” // Agriculture (Zemledeliye). 2022. No. 5. P. 46-48. https://cyberleninka.ru/article/n/effect-of-lowfrequency-electromagnetic-field-on-the-properties-of-wheat-and-barley-seeds

[4] *Jansen M.A.K., Gaba V., Greenberg B.M.* “Higher Plants and UV-B Radiation: Balancing Damage, Repair and Acclimation”// Trends Plant Sci. 2015. V.3. No 4. P. 131-135. https://www.researchgate.net/publication/242231656_Effect_of_PAR_and_UV-B_Radiation_on_the_Quality_and_Quantity_of_the_Essential_Oil_in_Sweet_basil_Ocimum_basilicum_L

[5] *Kasyinkina O. M., Bogun V. P.* “Presowing Treatment of Seeds of Winter Triticale Microwave Electromagnetic Field” // Agriculture (Zernovoye hozyaystvo). 2017. No. 5. P. 32-34. https://cyberleninka.ru/article/n/otsenka-effektivnosti-perspektivnyh-sposobov-predposevnoy-obrabotki-semyan-ozimoy-pshenitsy-na-osnove-analiza-sostoyaniya-posevov-i

[6] *Klassen V.I.* “Magnetization of Water Systems” / 2-nd ed. M.: Chemistry (Chimiya), 2018. 296 p. https://library.kpi.kharkov.ua/files/Vestniki/2022_2_hymyya_tehnologyya.pdf

[7] *Kozyrsky V.V., Savchenko V.V., Sinyavsky A.Yu.* "The Influence of the Magnetic Field on the Diffusion of Molecules Through the Cell Membrane of Seeds of Agricultural Crops".// Vestnik VIESH. 2014. No 2 (15). P. 16-19. https://www.researchgate.net/publication/337203596_Change_of_sowing_seed_quality_of_rye_seeds_after_treatment_in_magnetic_field

[8] Levina N.S., Tertyshnaya Yu.V., Bidey I.A., Elizarova O.V. Sowing qualities of seeds of soft spring wheat (triticum aestivum L.) under different modes of exposure to a low-frequency electromagnetic field" // Agricultural Biology. 2017. Vol. 52. No. 3. pp. 580-587 https://cyberleninka.ru/article/n/posevnye-kachestva-semyan-myagkoy-yarovoy-pshenitsy-triticum-aestivum-l-pri-raznyh-rezhimah-vozdeystviya-nizkochastotnym .

[9] *Mikhailenko I.M., Kanash E.V., Timoshin V.N.* "Models of Linear Plant Growth under Oxidative Stress Caused by UV-B Radiation"// Agricultural biology (Sel`skohozayastvennaya tehnologiya). 2024. No. 1. P. 17-25. https://cyberleninka.ru/article/n/modeli-lineynogo-rosta-rasteniy-v-usloviyah-okislitelnogo-stressa-vyzvannogo-deystviem-uf-v-radiatsii

[10] *Pardo G.P., Aguilar C.H., Martínez F.R., Canseco M.M.* “Effects of light emitting diode high intensity on growth of lettuce (Lactuca sativa L.) and broccoli (Brassica oleracea L.) seedlings”.// Annu. Res. Rev. Biol.. 2024. No 19. P. 2983-2994. doi: 10.9734/ARRB/2014/10526 https://journalarrb.com/index.php/ARRB/article/view/397

[11] *Savchenko V.V., Sinyavsky A.Y.* “Change of the Action Potential and Crop Yields with the Seed Treatment in a Magnetic Field” // Bulletin of VIESH. 2013. No 2 (11). P. 33-37. 10.31548/energiya2021.01.017

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ИМПУЛЬСТІ ТӨМЕН ЖИІЛІКТІ ЭЛЕКТРОМАГНИТТІК ӨРІСТІҢ БИДАЙ ТҰҚЫМЫНА ӘСЕРІ

Аңдатпа

Мақалада төмен қарқынды импульстік электромагниттік өрістердің жаздық бидай тұқымдарының физиологиялық және құрылымдық қасиеттеріне әсері жан-жақты қарастырылған. Жүргізілген зерттеу нәтижелері себу алдында мұндай өңдеудің тұқымның өну процесін жеделдететінін және жалпы биологиялық белсенділікті күшейтетінін көрсетті. Атап айтқанда, бақылау тобымен салыстырғанда сәулеленген тұқымдар әлдеқайда жылдам әрі жоғары пайызбен өнеді. Өскіндер мен тамырлардың массасы едәуір артып, өсімдік дамуының алғашқы кезеңінде жинақталатын энергия қоры күшейе түседі.

Оптикалық микроскопия әдісі арқылы алынған деректер дифференциалды сканерлеу калориметриясының нәтижелерімен толықтырылып, электромагниттік өрістің жасуша

құрылымында айқын өзгерістерге себеп болатынын дәлелдейді. Бұл өзгерістер крахмал түйіршіктерінің жаңа кристалдық формаларының түзілуімен және ерекше ассоциациялардың қалыптасуымен сипатталады. Мұндай құрылымдық қайта құрулар мембраналардың өткізгіштігін күшейтіп, су молекулаларының жасуша ішіне таралуын жеңілдетеді. Нәтижесінде тұқым тезірек ісініп, өнуі жылдам жүреді.

Сонымен бірге, минералды құрамдағы өзгерістер де байқалады. Ол өсімдік жасушаларының биохимиялық тепе-теңдігіне оң әсер етіп, физиологиялық үдерістердің белсенділігін арттырады. Жалпы алғанда, бұл зерттеу электромагниттік өрістерді ауыл шаруашылығы тәжірибесінде тиімді құрал ретінде пайдаланудың болашағы зор екенін айқындайды.

Кілт сөздер: импульстік төмен жиілікті сәулеленудің электромагниттік өрісі, сәулелену режимі, түйіршікті құрылым, оптикалық микроскопия

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ВЛИЯНИЕ ИМПУЛЬСНОГО НИЗКОЧАСТОТНОГО ЭЛЕКТРОМАГНИТНОГО ПОЛЯ НА СЕМЕНА ПШЕНИЦЫ

Аннотация

В статье подробно рассматривается влияние низкоинтенсивного импульсного электромагнитного излучения на клеточную структуру семян яровой пшеницы и на их физиологическое развитие. Полученные в лабораторных условиях результаты убедительно свидетельствуют о том, что предварительное облучение семян перед посевом оказывает выраженное положительное воздействие на их биологические характеристики. В первую очередь это проявляется в увеличении скорости и успешности прорастания, а также в приросте биомассы как ростков, так и корневой системы по сравнению с контрольными образцами.

Микроскопическое исследование срезов семян, подвергшихся воздействию электромагнитного поля, в сопоставлении с необработанными образцами выявило существенные различия в организации клеточных структур. Результаты дифференциальной сканирующей калориметрии подтвердили наличие глубоких изменений в процессах, происходящих на уровне крахмалсодержащих включений. Отмечено образование ассоциатов и специфических кристаллических форм крахмала, что способствует интенсификации обменных процессов.

Изменения в минеральном составе зерен усиливают диффузию воды через клеточные мембраны, благодаря чему набухание и прорастание происходят быстрее. В совокупности эти процессы ускоряют раннее развитие растений, повышая их устойчивость и жизнеспособность. Таким образом, проведенное исследование демонстрирует значительный потенциал использования электромагнитных полей в качестве инновационного инструмента для повышения эффективности сельскохозяйственного производства.

Ключевые слова: электромагнитное поле импульсного низкочастотного излучения, режим облучения, зернистая структура, оптическая микроскопия

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ТЕХНОЛОГИЧЕСКИЙ КОМПЛЕКС МАШИН ДЛЯ ВОЗДЕЛЫВАНИЯ И УБОРКИ САХАРНОЙ СВЕКЛЫ В УСЛОВИЯХ ЮГА, ЮГО-ВОСТОКА КАЗАХСТАНА

Аннотация

Проведен анализ имеющейся в хозяйствах техники для возделывания сахарной свеклы. В южной, юго-восточной зоне Казахстана сосредоточены почвы, подверженные иссушению, склонные к заплыванию и повышенной твердости. В результате традиционная технология возделывания сахарной свеклы в этих условиях не дает ожидаемого результата: оптимальную густоту стояния всходов, условия для роста растений и в конечном счете величину урожая, обеспечивающую окупаемость затрат и получение прибыли. Производство сахарной свеклы сосредоточено, в основном, в мелких и средних хозяйствах, которые в силу экономических причин не могут приобрести дорогостоящие почвообрабатывающие, посевные и свеклоуборочные агрегаты предлагаемые производителями зарубежных стран.

Традиционная технология возделывания сахарной свеклы включает вспашку, несколько предпосевных рыхлений почвы, выравнивание, посев, междурядную обработку на глубину до 14см и уборку корнеплодов. При этом в результате разрыва во времени между технологическими операциями по обработке почвы и посеву происходит иссушение почвы. Кроме того, почвообрабатывающие орудия для предпосевной обработки с пассивными рабочими органами не обеспечивают необходимое крошение почвы для последующего качественного посева семян сахарной свеклы.

В результате систематических поливов и высоких температур в июле, августе твердость почвы в междурядьях сахарной свеклы достигает высоких значений 3-4 МПА, что препятствует проникновению влаги к корням свеклы и газообмену. Серийно выпускаемые пропашные культиваторы обрабатывают междурядья на недостаточную глубину (12-14см).

Степень травмированности корней сахарной свеклы имеющимися в хозяйствах свеклоуборочными комбайнами превышает допустимую вкличину.

В связи с вышеизложенным, целью исследований является разработка технологического комплекса машин, обеспечивающего сокращение проходов машинно-тракторных агрегатов (МТА) по полю, сокращение разрыва во времени между технологическими операциями, высокое качество крошения почвы и посева семян, глубокую до 25см обработку междурядий сахарной свеклы, уборку корней свеклы с низкой повреждаемостью.

Для достижения поставленной цели будут разработаны культиватор вертикально-роторный для предпосевной фрезерной обработки почвы; сеялка комбинированная для предпосевной фрезерной обработки почвы и точного посева семян; универсальный культиватор для мелкой до 14см и глубокой до 25см обработки междурядий сахарной свеклы; свеклоуборочный комбайн адаптированный к почвенно-климатическим условиям региона и обеспечивающий низкую повреждаемость корней.

Ключевые слова: *сахарная свекла, возделывание, традиционная технология, культиватор вертикально-роторный, сеялка точного высева, культиватор для междурядной обработки, уборка корней, повреждаемость корней*