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Effects of Electrical Treatment on the Tissues of Grape Cuttings and Characteristics of the Equivalent Replacement Scheme

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Abstract. The article examines and scientifically substantiates the structures of grapevine tissues during electrical stimulation through electrical processing of materials related to plant growing, namely, that they depend on the active resistance of the mesoplasm of cells (R1), the active resistance of the intercellular system (R2), the active resistance of the protoplasmic membrane (R3) and cell membrane polarization (C). As a result, electrical switching circuits are presented for the equivalent equivalent circuit of a grapevine and the calculation of an electrical circuit in a classical way, which show the absorption of electromagnetic field energy in material environments and the implementation of technological work.

INTRODUCTION

An electromagnetic field can exist (manifest) in many forms, and these include electric fields, magnetic fields, electromagnetic waves, electric currents, and other electrical and magnetic phenomena. These forms deliver electrostatic, magnetic, electromagnetic, electrodynamic and other types of energy. The main reason for the greater use of electrodynamic or electrical energy is its easy generation, transmission and conversion into other types of electrical and non-electrical energy. All types of electromagnetic field energy have technological properties such as absorption in material environments and transformation into thermal, mechanical, chemical or biological energy. The content of electrotechnology is the conversion of electrical energy into other electrical and non-electrical types and its use in technological processes for the purpose of influencing the means of production (electrical acceleration).[1]

The conversion of electromagnetic field energy into other types is carried out due to the absorption of electromagnetic waves in the environment. The direction and intensity of conversion varies depending on the electrophysical properties of the medium and the frequency of the field. The main condition for energy absorption is the presence in the medium of "electromagnetic energy acceptors" - elementary free or bound electric charges with a vibration frequency not significantly different from the vibration frequency of the field. The closer these two frequencies are, the more energy is absorbed. This is manifested in the effects of electric stimulation or vice versa by electric processing of agricultural products belonging to the world of plants. Originating from the plant world, "free"

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electrons or currents move in conductors at relatively small frequencies of the field, as a result of which electronic or ionic conduction currents appear. It is known from the course of electrotechnology that part of the energy introduced into a medium is absorbed by the object being processed, part passes through and part returns. The work performed in electrical processing is due to absorbed energy. That is why the use of various effective methods and their correct selection is one of the important steps in introducing energy into technological processes.

During electrical processing, the flow of transient current generated under the influence of energy introduced into the medium leads to multiple collisions of free electrons in type 1 conductors and ions in type 2 conductors with ions of the crystal lattice, atoms and molecules of the substance. and causes the transfer of excess accumulated energy to them. As a result, the orderly motion energy of charges (electric current, transition current, displacement current, Foucault current, etc.) causes the transformation of the disordered (thermal, mechanical, chemical, biological, etc.) energy of atoms and molecules of matter. In this case, the charges in motion act as "intermediate energy carriers" (working bodies) that transfer field energy to molecules of matter. Today, electrical processing using electro technological methods based on the achievements of science is one of the promising directions, after the materials of plant origin. Today, in order to increase the level of root formation and tenacity in grape cuttings, they are pre-treated by various methods (mechanical, physiological, chemical, traditional, electrophysical, etc.) before planting in cuttings [2]. One of the effective methods is electrophysical (electric field, magnetic field, electric current, pulsed electromagnetic field, etc.) methods [3-6].

It is important to take into account the environment of the cuttings and the treatment process in electrical treatment before planting on grapevine cuttings [7]. P.P.Radchevsky, A.G.Kudryakov, V.A.Petrukhin and several other scientists conducted scientific research on the study of electrophysical effects on plant cuttings and lignified tree cuttings and improving the technology of growing seedlings. conducted and achieved positive results [8,9]. When grapevine cuttings are affected by electrical treatment before planting, their individual parts can be described as elements of an electrical circuit [10]. The characteristics of the grape stalk and agricultural products belonging to the plant world, i.e. plant elements, are determined by the methods of connecting the processed stalk to the power source and its structure. According to A.G. Kudryakov, the most correct way to pre-treat grape cuttings with electric current before planting is to deliver electricity to the cut areas of grape cuttings through a liquid conductive solution.

In this regard, in the world and in our Republic, special attention is being paid to the development of methods and tools that make it possible to accelerate their development, unify their vegetative development and increase their quality, as well as save energy and resources by treating the cuttings for grape seedlings with infrared, electromagnetic rays and electric current. [11,12]. Today, one of the most effective methods of electrical processing of materials of plant origin is the use of biological effects of electromagnetic field energy.

METHODS.

Using the biological effects of various forms of electromagnetic field energy, it is possible to electrify agricultural products through electrical treatment, and this has been proven based on the results of various scientific studies. In this case, electromagnetic waves weaken along the direction of propagation in the absorbing medium. It is possible to explain these technological processes as follows: the energy flow determined by the Poynting vector is a function of the distance "Z" from the surface of the environment and decreases according to the exponential law.

$$S_z = S_e\, exp(-2kz)\,; \tag{1}$$

in this: S_e – energy flow at the surface of the medium, V·A/m^2; k- wave attenuation coefficient, m^{-1};

Therefore, the attenuation intensity of waves, that is, energy absorption, is determined by the attenuation coefficient k, which is a function of the electrophysical properties of the medium and the frequency of the field. For absorbing media, this coefficient is expressed using the following formula [1].

$$k = \omega\sqrt{\frac{\varepsilon_0 \cdot \mu_0}{2}\left[\sqrt{1+\left(\frac{\gamma}{\omega Ea}\right)^2} - 1\right]} \tag{2}$$

in this: $\omega = 2\pi f$- angular velocity of the field, rad/s

$\gamma/\omega\varepsilon_a = 0$ $k = 0$ electromagnetic waves do not fade and energy is not absorbed in ideal dielectrics during electrical processing. As we know from the course of electrotechnology, the balance of the electromagnetic energy falling on the body for a system of bodies whose characteristics do not change and do not move in the absence of an external electric driving force, characterized by ε_a,μ_a,γ quantities, is expressed by the Umov-Poynting theorem.

$$-\oint \bar{\Pi} d\bar{A} = \int \gamma E^2 dv + \partial/\partial\tau \int_v \left(\frac{\varepsilon_a E^2}{2} + \frac{\mu_a H^2}{2}\right) dV \tag{3}$$

The illustrated equation (3) represents the law of conservation of electromagnetic field energy in the volume V: the energy flow falling in the form of the Poynting vector to the volume V bounded by the closed surface A per unit of time is spent on the release of joule heat in this volume and the change of the energy of the electromagnetic field.

$$\mathrm{T} = \int_v \gamma E^2 dV \tag{4}$$

$$\frac{\partial w}{\partial \tau} = \frac{\partial}{\partial \tau}\int_v \left(\frac{\varepsilon_a E^2}{2} + \frac{\mu_a H^2}{2}\right) dV \tag{5}$$

In this case, the expression (5) makes it possible to determine the changes that occur when the field changes over time. We describe the Umov-Poynting equation in complex form:

$$\dot{S} = -\oint \overline{\Pi}\, d\overline{A} = \int_v \gamma E^2 dV + j2\omega \int_v \left(\frac{\mu_a H^2}{2} - \frac{E_a E^2}{2}\right) dV \tag{6}$$

The real component of the right side of the equation represents the active power P, and the abstract reactive power Q. The full power in the system is expressed as follows.

$$S=P+jQ \tag{7}$$

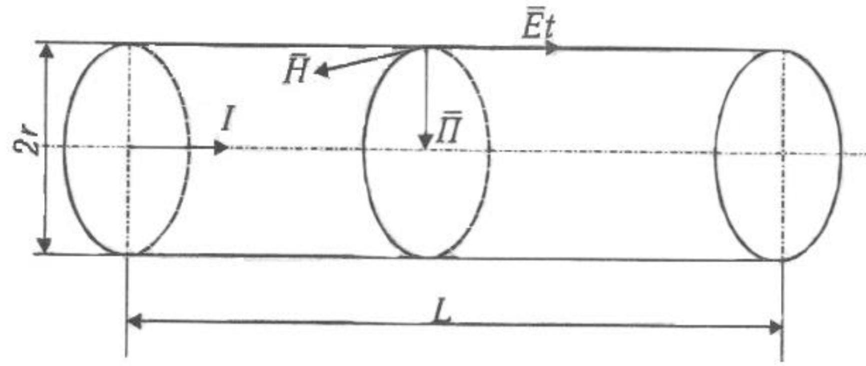

FIGURE 1. Movement of energy in a constant current conductor.

The strength of the electric field on the surface of the conductor corresponds to the direction of the current. (8) is expressed in the form of expression.

$$\overline{\mathrm{E}_t} = j/\gamma \tag{8}$$

From Fig.1, which describes the movement of energy in a constant current conductor, it can be seen that the Poynting vector is directed inside the conductor, that is, along the normal side.

$$\overline{P} = \left[\overline{E} \cdot \overline{H}\right] \tag{9}$$

So, the energy enters the conductor from the external environment through $A = 2\pi r l$surfaces. Energy does not enter the base of the cylinder, because the vector $\overline{P}$is directed perpendicular to it.

$$|S| = P = E_t H A = (j/\gamma)(jr/2)2\pi r\ell = (j^2/\gamma)\pi r^2 \ell = \gamma E^2 V \tag{10}$$

The energy flow per unit of time, that is, the expression of the Joule-Lence law in the differential form obtained on the basis of experience (11).

$$Q = \gamma E^2 V\tau = I^2 R\tau = U^2 \tau / R \tag{11}$$

In addition to the thermal effect of the electromagnetic field, it also has mechanical and chemical effects and has a certain effect on biological systems. Electrophysical and electrochemical methods are used to affect a certain object by changing electrical energy or directly using the "improper" effects. They are based on various manifestations of the electromagnetic field (mass transfer, polarization, directional phenomena), and the course of the process is more influenced by its shape, frequency, etc. [1].

In agricultural production, electricity is used in the following main areas: processing of nutrients to increase the efficiency of their use; decontamination of agricultural environments; taking disinfectant mixtures; influencing the life activity of seeds and plants in order to stimulate or stop them; land reclamation; drying of wet materials; electro flotation; water desalination and activation; is manifested in electrochemical processing.

Therefore, considering the plant tissue (grape stalk) under the influence of alternating electric current as one of the elements of the electrical circuit reveals the physical essence of the technological process. Today, almost 90% of quality grape seedlings are grown mainly by vegetative methods. In this case, the retention of vine cuttings is on average 65-80%, and 20-25% of the planted cuttings remain without bruising [13]. Today's science is proving that it is possible to increase the level of resistance by electroplating the cuttings before planting them. In this case, one of the most important issues is to find ways to introduce energy into grapevine cuttings and to determine ways to effectively introduce it into the environment, as well as scientific justification of influencing parameters. [14,15].

Statistical data, experimental results and theoretical research processing methods were used in the research. On the basis of the results of the experiments carried out in this case, the scientific hypothesis put forward through theoretical research and acceptance of the conclusions and the influencing factors are: 1. the resistance of the internal parts of the cells (cytoplasm), 2. the external environment (intercellular space), 3. the protoplasmic membrane (cell membrane) resistance and 4th cell wall capacitance will be determined.

RESULTS AND DISCUSSIONS.

The scheme of equivalent replacement of plant tissue depends not only on the nature of the electrical effect, but also on its compositional and quantitative properties. Therefore, it is important to determine the electrical properties of plant tissues before and after electrical effects [16]. Therefore, plant tissue can be imagined as an element of an electric circuit, its properties make it possible to determine the nature and quantitative parameters of the indicated electric effects and allow to determine it [17]. One of the best ways to study the structure of such tissues as a conductive medium is to determine the relative electrical resistance and electrical conductivity of crushed plant tissue.

Measurements are carried out in various high-frequency alternating currents [18]. One of the main methods of studying the structure of plant tissues as total conductivity is based on measuring the electrical conductivity of plants or grape cuttings. Measurements are made in alternating current of different frequencies.

The scheme of equivalent replacement of plant tissue should take into account its anatomical structure. At the same time, the elements representing the most important components of the plant are clearly distinguished [5,19]. According to scientists such as A.G. Kudryakov and V.A. Petrukhin, who carried out effective scientific research on the electrical stimulation of woody plants, the diagram of stem tissue of woody plants should include at least 4 elements (see Fig.2). These include the following. 1. The resistance of the internal parts of the cells (cytoplasm), 2. The external environment (intercellular space), 3. The resistance of the protoplasmic membrane (cell membrane) and 4. The capacitance of the cell wall [5,19]. The scheme of equivalent substitution of plant tissue is shown in Fig. 2.

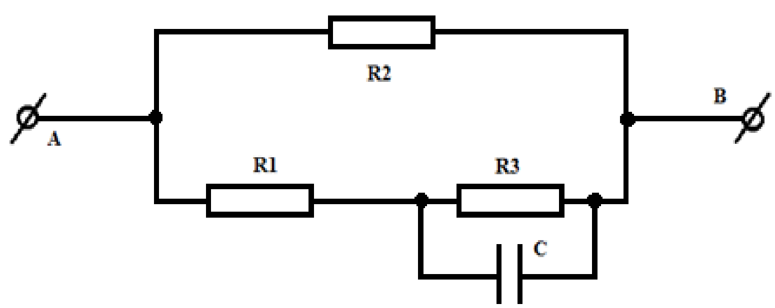

FIGURE 2. Scheme of equivalent replacement of grape cuttings.

Since the organs in plant and animal cells are similar in molecular structure and chemical composition, their functions are also similar. This indicates that plant and animal organisms have a common origin. Each cell is a whole independent unit, surrounded by a plasma membrane or plasmalemma. The cell communicates with the external environment through this plasmalemma. As a result, it is supplied with nutrients. One of the features common to all cells is the presence of cytoplasm and deoxyribonucleic acid, which carries genetic information.[20] Generally, a plant cell consists of three parts: the cell membrane, which is composed of carbohydrate compounds and covers the surface of the cell. The protoplast is the most important living part of the cell and is located around the walls of the cell membrane. Finally, the center of the cell is the vacuole (nucleus). In the vacuole there is cell sap, in which water-dissolved carbohydrates, proteins, salts, alkaloids and other compounds accumulate.[21]

The above information allows you to understand the biological condition of the grape stalk. The active resistance of the mesoplasm of R_1-cells is depicted by the equivalent replacement scheme of the grape cutting; R_2-active resistance of the intercellular system; R_3-active resistance of the protoplasmic membrane; C- means polarization of cell membranes. Taking into account the above, we can use the equivalent switching circuit shown in Fig.2 to calculate the electrical circuit of the grape stalk in the electrical processing in the classical way, the electrical switching circuit can be depicted in the form of Fig.3 [5.22-24].

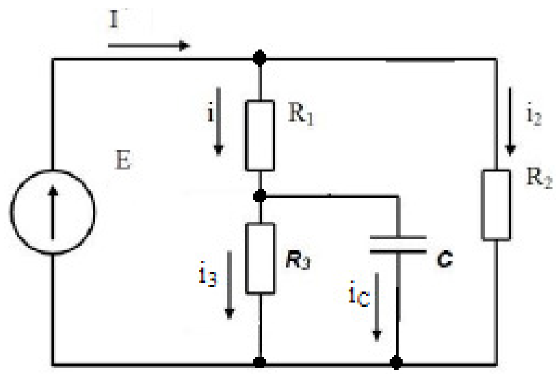

FIGURE 3. Electric switching scheme for calculating the electric circuit in the classical way.

We determine the initial conditions using the circuit diagram

$$U_{C0-} = U_{C0+} = 0 \tag{12}$$

We construct a system of differential equations

$$\begin{cases} I - I_1 - I_2 = 0 \\ I_1 - I_3 - I_C = 0 \\ I_1 R_1 + I_3 R_3 = E \\ \frac{1}{C}\int I_C dt - I_3 R_3 = 0 \\ I_2 R_2 - \frac{1}{C}\int I_C dt - I_1 R_1 = 0 \end{cases} \tag{13}$$

We construct a parametric equation using the scheme of equivalent substitution of plant tissue and find its root

$$Z_P = \frac{\frac{R_2 \cdot R_1 + R_1 \cdot R_2 \cdot R_3 \cdot PC + R_2 \cdot R_3}{1 + R_3 \cdot PC}}{\frac{R_2 + R_1 + R_1 \cdot R_3 \cdot PC + R_3}{1 + R_3 \cdot PC}} \tag{14}$$

By reducing the denominators of the expression (14), equation (15) takes the form

$$Z_P = \frac{R_2 \cdot R_1 + R_1 \cdot R_2 \cdot R_3 \cdot PC + R_2 \cdot R_3}{R_2 + R_2 \cdot R_3 \cdot PC} = 0 \tag{15}$$

$$R_1 \cdot R_2 + R_2 \cdot R_3 + R_1 \cdot R_2 \cdot R_3 \cdot PC = 0 \tag{16}$$

$$P = \frac{-R_1 \cdot R_2 - R_2 \cdot R_3}{R_1 \cdot R_2 \cdot R_3 \cdot PC} \tag{17}$$

Let's determine the direct current

$$I_{tur} = \frac{E}{\frac{(R_1 + R_3) \cdot R_2}{R_1 + R_3 + R_2}} = E \cdot \frac{R_1 + R_2 + R_3}{R_1 \cdot R_2 + R_2 \cdot R_3} \tag{18}$$

We construct a system of differential equations for the case of $t = 0$

$$\left.\begin{matrix} I_0 - I_{10} - I_{20} = 0 \\ I_{10} - I_{30} - I_{C0} = 0 \\ I_{10} R_1 + I_{30} R_3 = E \\ U_{C0} - I_{30} R_3 = E \\ I_{20} R_2 - U_{C0} - I_1 R_1 = 0 \end{matrix}\right\} \tag{19}$$

$$I_0 = I_{tur} + A; \quad I_{30} = \frac{U_{C0} - E}{R_3}; \quad I_{C0} = 0; \quad I_{10} = I_{30}; \quad I_{20} = \frac{U_{C0} + I_{10} \cdot R_1}{R_2}; I_{t0} = \frac{U_{C0} - E}{R_3} + \frac{U_{C0} + I_{10} \cdot R_1}{R_2} = \frac{R_2(U_{C0} - E) + R_3(U_{C0} + I_0 R_1)}{R_2 \cdot R_3} \tag{20}$$

We find the integration constant

$$A = I_0 - I_{tur} = \frac{R_2(U_{C0} - E) + R_3(U_{C0} + I_0 R_1)}{R_2 \cdot R_3} = \frac{-E(R_1 + R_2 + R_3)}{R_1 \cdot R_2 + R_2 \cdot R_3} \tag{21}$$

The time-defined value of the current function is determined by the following expression

$$I_t = E \cdot \frac{(R_1+R_2+R_3)}{R_1 \cdot R_2 + R_2 \cdot R_3} + \left(\frac{R_2(U_{C0}-E)+R_3(U_{C0}+I_0 R_1)}{R_2 \cdot R_3} - E\,\frac{-E(R_1+R_2+R_3)}{R_1 \cdot R_2 + R_2 \cdot R_3}\right) \cdot e^{Pt} \tag{22}$$

Previous scientific studies [5,17,20]. It became a source of clarification of the scientific views related to the electrical stimulation of grape nova cuttings by electrical treatment. It can be seen from the formula (22) expressed in the time-defined value of the current function that starting from a certain threshold value of the voltage, the capacitive component of the plant tissue conductivity becomes zero, and its conductivity has an active character. ladi [20]. Therefore, it is possible to consider its resistance as an active characteristic during electrical processing of grape vine cuttings.[25]

On the basis of research, the polarization of the C-cell membranes, i.e., the capacitance component (X_C) in the equivalent replacement scheme of the grape stalk shown in Fig.2, the complete resistance of the rod (Z), the active resistance of the mesoplasm of R_1 cells, the R_2 intercellular system consists of active resistance and active resistance of R_3-protoplasmic membrane. This made it possible to think that the use of alternating electric current has an effective effect in the electric stimulation of grape cuttings by electric treatment before planting.[26]

CONCLUSION

The following conclusions were reached during the determination of the methods of introducing energy into materials of plant origin (grape stalks) and tissue conductivity.

1. It is possible to electrify it by electric treatment of materials of plant origin. As a result, it was determined that the tissues of the grape vine can be considered as a part of the electrical circuit.

2. The results of the previous researches showed that during the processing of grape cuttings by various mechanical, physiological, chemical and traditional methods, excessive physical labor is increased by an individual approach to each cutting. As a result, it was determined that it is necessary to update, improve and effectively use electrotechnological methods of processing grape cuttings.

3. The diagram of cuttings is one of the important parameters in the development of grape cuttings by electrical treatment. As a result, it was found that the grapevine stem contains

4 elements, that is, the internal part of the cells (cytoplasm), the external environment (intercellular space), the resistance of the protoplasmic membrane (cell membrane) and the capacitance of the cell wall.

5. It was studied that the anatomical structure of the plant tissue should be taken into account when expressing the scheme of equivalent substitution. As a result, it was determined that the equivalent switching scheme of the grapevine stem depends on the active resistance of the mesoplasm of the cells (R_1), the active resistance of the intercellular system (R_2), the active resistance of the protoplasmic membrane (R_3) and the polarization of the cell membranes (C) or the reactive resistance (X_C).

6. Electrical processing of grape vine cuttings was calculated using the classical method of differential equations. As a result, starting from a certain threshold value of voltage, the capacitive component of plant tissue conductivity becomes zero and its conductivity becomes active. Therefore, it was found that its resistance can be considered as an active characteristic during the electrical treatment of grape vine cuttings.

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