Treatment of potato tubers before planting in a magnetic field

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Abstract. The results of research on the impact parameters of treatment of potato tubers in a magnetic field to change their biopotential and yield are presented. The optimum regimes of treatment were determined.

Key words: magnetic field, magnetic treatment of potatoes, magnetic induction, speed of the conveyor, biopotential.

INTRODUCTION

Currently, potato yields in Ukraine are low - (120-140) kg / ha. To improve the growing efficiency, a growing effort in the application of energy-saving technologies has been visible, including one the most promising, i.e. magnetic treatment of potatoes.

Magnetic treatment of potatoes compared with other electro-physical methods is a highly energy efficient and safe for staff method.

The determination of the parameters of a potato in a magnetic field, examination of the field’s impact on the change of electro-physical parameters and yield of potatoes, will make it possible to substantiate constructional parameters and develop the equipment for magnetic treatment of potatoes.

The purpose of research was to increase potato yields by direct action of a magnetic field on them before planting.

MATERIALS AND METHODS

Theoretical study of a magnetic field’s influence on the change of potato biopotential was conducted based on the theory of collisions.

Experimental study of the changes of biopotential in magnetic potato treatment was performed on the specially designed laboratory installation with electromagnets. Gradient magnetic field was created by four inductors, switched-opposite parallel. Magnetic induction in air gap inductor regulated DC voltage changes applied to the coil inductors. The magnitude of the magnetic induction was measured by teslameter. The speed of potatoes transfer through a magnetic field, created by inductors, was being changed by the frequency converter Delta VFD004EL43A. Platinum measuring and auxiliary electrode was put into potatoes and measured redox potential of the potato before the magnetic treatment and after it by pH-meter-millivoltmeter.

In the study of the influence of magnetic induction on the change of potato biopotential, magnetic induction in air gap inductor changed within 0 - 50 mT at the speed of the potatoes through a magnetic field 1.0 m / s, which corresponds to the speed of conveyors in the production lines treatment of potatoes before planting.

The study of the conveyor belt speed’s impact at the magnetic treatment of potatoes on the change of biopotential was performed using the method of experiment planning. During the study, orthogonal central-composite plan was applied (Table 1) [1].

On the basis of one-factor experiments, the change was observed in magnetic induction of 15 ... 45 mT, as well as the values of top, bottom and core-level factors, the change of the conveying speed limit was 0.5 ... 1.5 m / sec.

Field studies of potato variety “Lugovska” carried out under the scheme: 1-and variant (control) – the potatoes were grown without treatment in a magnetic field; 2nd option – before planting, potatoes were treated by in a magnetic field with magnetic induction of 13 mT; 3rd option – with magnetic induction of 20 mT; 4th option – with magnetic induction of 30 mT, 5-th option - with the magnetic induction of 45 mT.

Experiments were performed in fourfold repetition. Research areas, an area of 20 m², were located by the usual repetitions. Effect of magnetic treatment on pota-
RESULTS AND DISCUSSION

In potato tubers various chemical and biochemical reactions occur that are inherently mainly oxidation-reduction. Stimulation of a potato is associated with an increase in its velocity due to changes in activation energy caused by the action of Lorentz force on ions [2]. Changing the activation energy and causing the change of velocity of chemical reaction causes a change in potato biopotential. Using the equation of Van’t Hoff-Arrhenius and Nernst it was found out that the change in magnetic field processing of biopotential was proportional to change in activation energy [3]:

\[ \Delta \Phi = 2.3^2 \frac{\Delta E_a}{zF}, \]  

where: \( E_a \) – activation energy; \( z \) – charge of ion; \( F \) – Faraday number.

According to the theory of collisions, chemical effects of collisions depend on the kinetic energy of relative motion along the line of centers [4]. The magnetic treatment of potatoes as a result of Lorentz force changes the normal component of ion velocity \( v_n \), (Fig. 1):

\[ \Delta v_n = v \cdot (\cos \beta - \cos \beta), \]  

or

\[ \Delta v_n = r \cdot q \cdot B \cdot (\cos \beta - \cos \beta) / m, \]  

where: \( r \) – radius of the circle on which the movement of the ion occurs; \( q \) – charge of ion; \( B \) – magnetic induction; \( m \) – mass of the ion, \( \beta_n \) and \( \beta \) – the angle between the velocity vector and the line connecting the centers of particles, respectively, with magnetic treatment and without magnetic treatment.

As follows from expression (3), changing the normal component of ion velocity depends on the magnetic induction, type of ions (their mass and charge) and number of the reverse (respectively angle \( \beta_n \)).

Due to changes in the normal component of the velocity of ions, changes occur in the kinetic energy of relative motion of particles along the line of centers:

\[ \Delta E_a = \frac{\mu}{2} \cdot \Delta v_n^2 + \mu \cdot v_n \cdot \Delta v_n, \]  

where: \( \mu \) – reduced mass of particles.

Subject to (3) the expression (4) will be rewritten as:

\[ \Delta E_a = \frac{H \cdot K^2 B^2}{2} + K \cdot \mu \cdot v_n \cdot B, \]  

where: \( K \) – coefficient, which depends on the type of ions and number of the reverse:

\[ K = r \cdot q \cdot B \cdot (\cos \beta_n - \cos \beta) / m. \]

Then the biopotential change:

\[ \Delta \Phi = 2.3^2 \frac{K \mu}{zF} \left( \frac{KB^2}{2} + v_n B \right). \]

Studies have shown that it is possible to estimate change of activation energy and determine the effect of magnetic treatment appropriate for the change of biopotential. To do this, measure the redox potential of the potato before the magnetic treatment and after it, and compare their difference with the value of the expanded measurement uncertainty, which is 2 mV.

Dependence of biopotential change on magnetic induction in the magnetic treatment of potato at the speed of the conveyor 1 m/s is shown in Fig. 2. When changing magnetic induction from 0 to 30 mT, potato biopotential grows, and with further increase of magnetic induction – it falls. The dependence of potato biopotential on magnetic induction is described by the equation:

\[ \Delta \Phi = -0.0272 B^2 + 2.1362 B. \]  

Curves 2 and 3 (Fig. 2) show changes in potato biopotential, measured in two weeks and a month after magnetic treatment. As follows from the presented dependences, potato biopotential practically does not change within one month after treatment.

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Fig. 1. Figure ion collisions

\[ \Delta v_n = v \cdot (\cos \beta - \cos \beta), \]

or

\[ \Delta v_n = r \cdot q \cdot B \cdot (\cos \beta - \cos \beta) / m, \]

where: \( r \) – radius of the circle on which the movement of the ion occurs; \( q \) – charge of ion; \( B \) – magnetic induction; \( m \) – mass of the ion, \( \beta_n \) and \( \beta \) – the angle between the velocity vector and the line connecting the centers of particles, respectively, with magnetic treatment and without magnetic treatment.

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Table 1. Investigation of changes in potato biopotential after magnetic treatment

<table>
<thead>
<tr>
<th>Number point</th>
<th>ɏ₀</th>
<th>ɏ₁</th>
<th>ɏ₂</th>
<th>Energy dose, J • s/kg</th>
<th>ɏ₁/ɏ₂</th>
<th>ɏ₂/ɏ₁</th>
<th>ɏ₁ - ɏ₂</th>
<th>ɏ₁/ɏ₂ - ɏ₂/ɏ₁</th>
<th>ΔBI, mV</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>1/3</td>
<td>1/3</td>
<td>+</td>
<td>0.115 35</td>
<td>-0.015 -0.036</td>
<td>35</td>
</tr>
<tr>
<td>2</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>1/3</td>
<td>1/3</td>
<td>-</td>
<td>1.035 36</td>
<td>-1.015 -1.036</td>
<td>36</td>
</tr>
<tr>
<td>3</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>1/3</td>
<td>1/3</td>
<td>-</td>
<td>0.037 23</td>
<td>-0.015 -0.036</td>
<td>23</td>
</tr>
<tr>
<td>4</td>
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<td>+</td>
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<td>1/3</td>
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<tr>
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<td>-</td>
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<td>-0.015 -0.036</td>
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</tr>
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<td>1/3</td>
<td>0</td>
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<td>0</td>
<td>-2/3</td>
<td>1/3</td>
<td>0</td>
<td>0.152 38</td>
<td>-0.147 -0.152</td>
<td>38</td>
</tr>
<tr>
<td>8</td>
<td>+</td>
<td>0</td>
<td>+</td>
<td>-2/3</td>
<td>1/3</td>
<td>0</td>
<td>0.152 38</td>
<td>-0.147 -0.152</td>
<td>38</td>
</tr>
<tr>
<td>9</td>
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<td>0</td>
<td>-2/3</td>
<td>-2/3</td>
<td>0</td>
<td>0.23 42</td>
<td>-0.223 -0.250</td>
<td>42</td>
</tr>
</tbody>
</table>

The measurement of conveying speed impact and energy dose needed in magnetic treatment of potatoes to change their biopotential was the planned method of the experiment (Table 1). Based on multifactorial experiment, regression equation was obtained for biopotential change, that for the 5% significance level has the form:

$$\Delta BI = 24.12 + 1.44B - 19.66v + 0.57Bv - 0.027B^2,$$

where: $v$ – velocity of the conveyor belt.

Dependence of changes in potato biopotential on magnetic induction and the speed of conveyor belt at the magnetic treatment is shown in Fig. 3.

Dependence of potato biopotential change on energy dose during treatment is presented in Fig. 4. As follows from the dependence, the biggest change in potato biopotential is observed at energy dose of 0.23 J • s/kg, which corresponds to the magnetic induction of 30 mT and the conveying speed of 1 m/s.

The prescribed mode of magnetic treatment of potatoes causing change in their biopotential was tested by examining yield and biometric indices of potato plants after magnetic treatment in accordance with the known methods of field experiments [5].

As a result of field studies it was found out that the best biometric performance and yield of potatoes were obtained at the magnetic induction of 30 mT and speed of conveyor belt 1 m/s (dose of treatment 0.23 J • s/kg). When increasing or decreasing the dose of treatment, biometric parameters and yield of potatoes decreased, but remained higher compared to potatoes untreated in a magnetic field (Fig. 5).

On the basis of studies, electro-technological facility for magnetic treatment of potatoes was established, which includes conveyor and device for magnetic treatment of potatoes (Fig. 6). Device for magnetic treatment of potatoes consists of 4 pairs of permanent magnets based on NdFeB, laid parallel above and below the belt conveyor with variable polarity. Magnets are glued to steel plates, and the intervals between them are filled with textolite.
The transporter frame in the area of placement of device for magnetic treatment is made of stainless steel. Its drive is carried out by three-phase asynchronous electric motor via step-down reducer.

CONCLUSIONS

On the basis of the studies it was found out that the most appropriate mode of magnetic treatment of potatoes before planting is the magnetic induction at 30 mT at the fourfold repetition and the speed of conveyor belt 1 m/s. Yield of potatoes at magnetic treatment before planting increases by 17…21 %, quantity of commodity tubers increases by 15 %, the starch, vitamin C, dry matter content in potato tubers treated in a magnetic field increase by 3…4 %, and the concentration of nitrates is reduced by 6 %.

REFERENCES