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A priori data on pre-sowing treatment and primary experiments on electric heating of onion seeds

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Abstract. Currently, Uzbekistan is among the twenty most advanced countries in the cultivation of onions. The onion plant was interpreted as a symbol of life in ancient Greek mythologies. Onion is one of the most widely consumed foods in the world due to its essential health and preventive properties, as one of the most essential fruits in the kitchen in the daily diet. The article studies the methods of processing onions before planting based on an analysis of the countries of the world. The results of studies of the influence of various electrophysical parameters on onion seeds are presented analytically. The effective influence of the electric field strength on the health of seeds is explained. The authors also referred to the results and methods of scientific research conducted at NRU "TIIAME" and analyzed the electrical and mechanical properties of onion seeds based on specific experiments. In particular, we analyzed the mass of 1000 seeds, the filling factor of the cubic container, and the initial (primary) results of determining the electrical and thermal conductivity of soaked seeds. The article also provides information on the impact of alternating electric current on onion seeds, developed special electrodes for determining electrical resistance, and a methodology for conducting research experiments. An electrical circuit is presented that ensures the completeness of seed treatment. There are also materials on the positive effect of "electrically activated" water on the additional health of soaked onion seeds. It is shown that the necessary conditions have been created for the process of automated intelligent control of the temperature of soaked onion seeds.

1. Introduction

Until now, when growing onions in our republic, many regulatory rules have been violated. For example, during the period when the temperature was the highest (40-50°C), pesticides were used many times more than the norm, mainly bitter varieties were grown. It has a shape, weight, but in most cases it is completely harmful to humans. At one time, tons and tons of products were obtained in this way, and the lands from which these products were obtained were turned into fields that did not yield crops for 50 years, and the humus layer of the soil was lost.

A scientific approach to onion cultivation, land protection, efficient use of environmentally friendly technologies in onion cultivation will give results [1]. The electrical technology we offer is based on the use of mechatronic systems with electrical technology, which reduces the manual labor of a person when growing onions [2], is environmentally friendly and reduces water consumption.

In order to systematize the work on the development of land areas along the edges of the fields of farms of the republic, the cultivation of agricultural products on them and the organization of their guaranteed purchase, assigning a separate responsible organization to this system, as well as financial support for land owners along the edges of fields, a resolution of the President of the Republic of Uzbekistan dated 12 April 2023 signed PQ-121. This regulatory document opens up new opportunities for growing onions in new ecological ways in the republic.

It is known that Uzbekistan is currently one of the twenty most advanced countries in the world in the cultivation of onions. In 2016, global onion production was 93.1 million tonnes, with China and India accounting for over 45% of global production. However, there has been no growth in onion production in China in recent years. Examples of countries with high growth dynamics for the analyzed years are shown in Figure 1. On the y-axis in the drawings below, the unit of measurement is given in thousands of tons. The abscissa shows years in ascending order.

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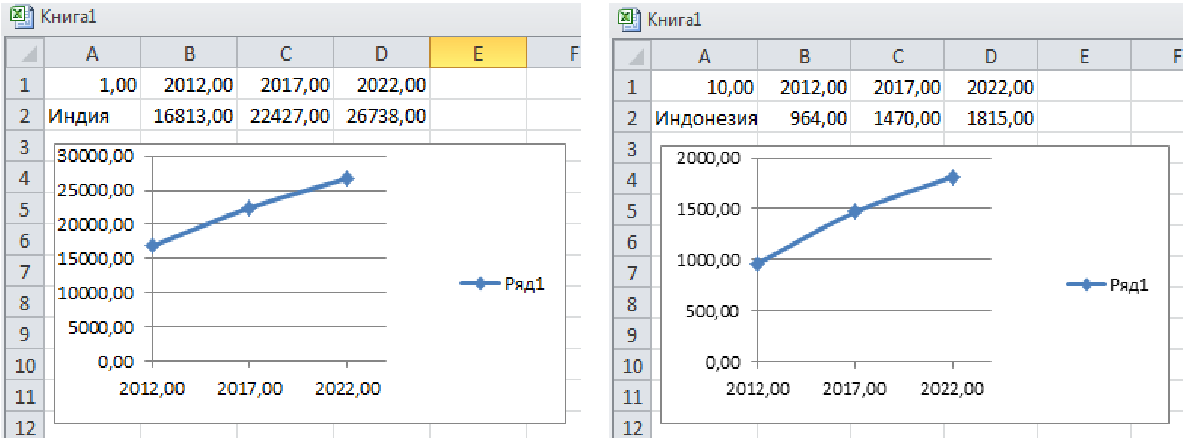


a *b*

Fig. 1. Examples of countries with high dynamics of onion cultivation in the world: a-India; b- Indonesia

Below is an analysis of a priori data on the pre-sowing treatment of onion seeds. In her article, T. A. Dvoryashina considered the effectiveness of a healing pre-sowing treatment of seeds in relation to the yield of onions. It was found that Probiotic (1:100), Eco-Organic (0.1), treatment with silver nanoparticles (30 ppm) resulted in the formation of onion bulbs (Allium cepa L.) with a diameter of 15.1-22. mm from 71.5 to 84.0% [3]. In these studies, Prateik Santosh Harat et al. concluded that initial treatment, seed age, and their interaction had significant differences in all seed qualities studied. All treatments improved seed quality of freshly harvested as well as annual seeds, and GA3 at 100 ppm for 24 hours (T8) was found to outperform all other treatments statistically equal to T7. i.e. GA3 at 100 ppm for 12 hours. Treatment with T11, i.e. control (untreated), recorded the lowest values in both batches of seeds [4]. Magnetic fields affect the physiological development of onion seeds and seedlings. However, for a greater impact, the genotype, time and intensity of exposure should be taken into account, since many studies have shown a positive effect of a magnetic field on crop yield [5].

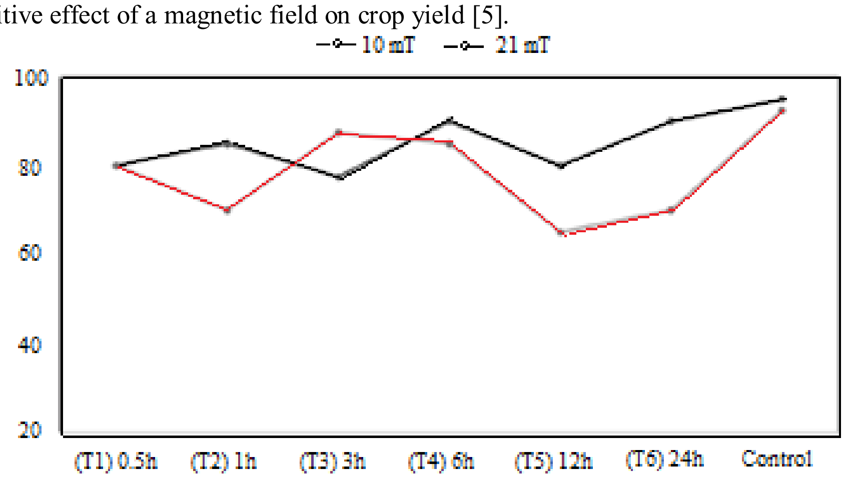


Fig. 2. Effect of static magnetic field treatments on the germination percentage of onion seeds

No interactions were found between the main effects assessed. The results of the permeability test obtained with different treatments showed that there is a similarity in the estimated concentration of magnetization. It was found that the percentage of seed germination ranges from 77.5% to 95% for magnetic stimulation with a magnetic field intensity of 10 mT and from 65% to 92.5% for a magnetic field of 21 mT [5]. It was found that all variants have a lower percentage of germination than the control at a magnetic excitation intensity of 10 mT. The highest percentage of germination was the same as in the control (95%); the lowest percentage of germination was 77.5% for a three-hour treatment, but the difference between treatment and control was not significant. As a result, it was found that there is an interaction between two experimental factors (magnetic field strength and exposure time) (Fig. 2).

Recently, many authors have noted that the magnetic field affects seed germination, seedling growth and meristem cell growth and chlorophyll content [7]. The positive effect of a magnetic field on photochemical activity, respiration rate, and enzymatic activity was studied [6].
Based on a study by Kubisz L et al. it is shown that it is very important to consider that the Magnet treatment consists of seeds placed inside a magnet in Petri dishes with sterile and distilled water. According to [8], it was found that the response of onion seeds to magnetic treatment could be affected by seed moisture during magnetic treatment. The results obtained in this study contradicted the data that onion seeds treated with magnetic fields germinated better; however, results have shown that it does not always show an improvement in germination [8]. In experiments carried out on onions [8], they found clear differences in the length of the roots and the wet weight of the seedlings, showing that the primary root fibers of the seeds exposed to the magnetic field were longer than those of the control. It was found that seeds treated with a 21 mT magnetic field had a higher fresh weight at exposure times of 1, 6, 12 and 24 hours compared to seeds treated with a 10 mT magnetic field. Bai et al. investigate the biological effects of a 4 kV/m electrostatic field on barley seeds and 4.5 kV/m sugar beets for 10 minutes. Their results showed that electrostatic fields of a certain intensity can increase the amount of free radicals in seeds [9]. Rotcharoen et al. studied the effect of electric field on rice growth and found that electric field strengths of 193 kV/m and 4 kV/m had a significant effect on the growth rate and height of rice plants [10]. Vasilevsky showed the benefits of electric and magnetic fields in agriculture in the following way. In addition to its low-cost application, it has identified its potential to reduce toxicity and pollution of surface and groundwater, ultimately reducing the cost of agricultural production and increasing yields. Increase in seed germination by 20-30% and decrease in the number of planted seeds by 30%, increase in root size by 24%, increase in plant weight by 10-45% and increase in yield by 10-50%. is the result of field work [11]. Forug Molamofrad et al. attempted to analyze this aspect of the electric field and exposure time using onion seeds as an experimental system. In this article, the effects of an AC electric field and exposure time on germination percentage, germination rate, seedling growth, and dry weight were studied in a laboratory setting. Onion seeds of the onion variety Azarshar (Allium cepa) were used as the material. To study the effect of high voltage AC electric field on onion seeds in laboratory conditions, germination tests and growth tests were carried out. Onion azarshahr (Allium cepa) seeds were supplied by the Institute of Breeding and Seed Production, Karaj, Iran, which is claimed to provide high seed viability and uniformity, thereby guaranteeing reliable results without the need for large scale production [12]. Onion seeds are placed in nylon bags of a certain weight for operation on electricity, depending on the strength of the electric field and the duration of the field exposure to the seeds. After that, an electric field was applied to the nylon bags. An alternating voltage is applied to this field. The dimensions of the placement of two chambers were 25 and 5 cm, respectively (Fig. 3). The electric fields used for seed treatment ranged from 2 to 14 kV/cm, and the time was from 15 to 150 seconds [12]. After appropriate electrophysical treatment of seeds, batches of 50 seeds were prepared and collected in three repetitions in sterile Petri dishes with filter paper (Fig. 4) [12].

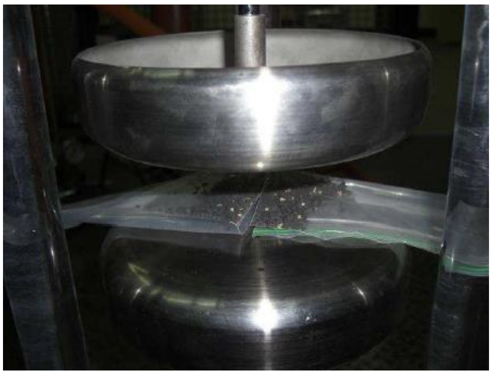


Fig. 3. Seeds of Onion between two field chambers

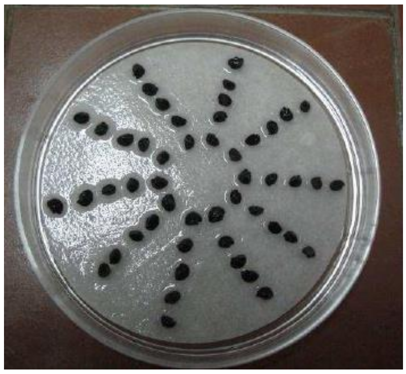


Fig. 4. Schema of Petri Dish containing Seeds

Forough Molamofrad et al [12] the following conclusions have been made from this study:
1. The higher percent germination enhancement was obtained at 9kV/cm.
2. The maximum height increase of seedling was achieved at 4kV/cm.
3. The best germination rate and dry weight of seedling enhancement were obtained at 2kV/cm.

4. The maximum increase in reminded characteristics was obtained during time period of 15- 45s.
F. Effendi et al. are currently conducting research and their results show that seed pre-treatment can indeed increase the planting value of New Zealand onions in terms of establishment rate. It is also noted here that polyethylene glycol encapsulation may be more advantageous than brine encapsulation, especially since the seeds must be dried to the initial moisture level for normal processing. However, it has been suggested that process economics for cell transplantation systems need to be carefully evaluated, especially when differences in reactions between seeds need to be considered [13]. Research by Barbara Yagosh shows that two osmotic solutions, PEG 6000 and PEG 8000, affect the percentage of normal and abnormal seedlings, MHT seeds of onion Wolska. Seed treatment at - 1.0 MPa resulted in higher germination and lower MGT than treatment at - 1.5 MPa. Compared to the control, both osmotic potentials improved growth characteristics. Compared to control, both treatment temperatures were tested and improved germination characteristics, but seed treatment at 20ºC gave better results than at 15ºC. The optimal ratio of normal and abnormal seedlings was obtained after 24 hours at - 1.0 MPa at 20 °C and 48 hours at - 1.5 MPa 72 hours at - 1.0 MPa at 20 °C It was shown that the treated seeds germinated in 2 times faster than control [14].

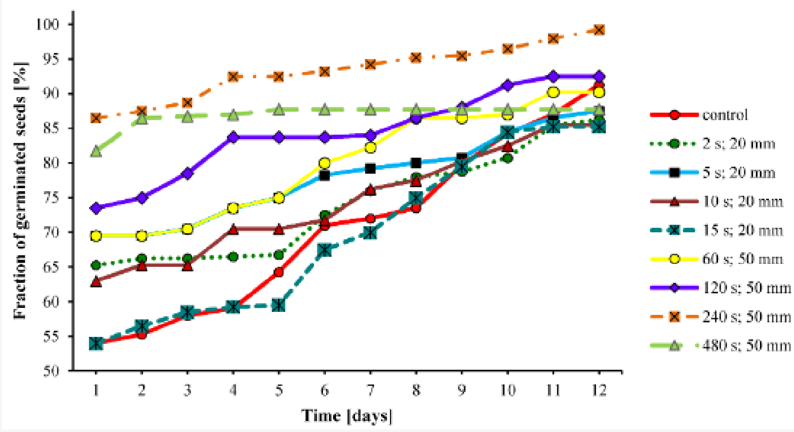


Fig. 5. Fraction of germinated onion seeds after pre-sowing plasma treatment

Wójcicka A et al. [15] concluded that an important feature of seeds is their rapid germination and the formation of healthy seedlings within a certain time. The dynamics of the process of germination of onion seeds treated with plasma is shown in Figure 5 in the article. As a result of research conducted by A. Wójcicka, changes in the structure of the surface of onion seeds treated with plasma turned out to be very subtle and almost imperceptible. Sharp and harmful changes, for example, the disintegration of the outer layer, are not observed even during the longest treatment of the seed. However, small differences in the cell surface of the seed coat may indicate a change in cell pressure [15]. In this study by Hatun I. and Hossen R., who investigated the effect of temperature on onion seed germination, the researchers experimented with onion seeds at 6 different temperatures (15°C to 40°C). According to the results of the experiments, different growth results were obtained, different temperatures were observed. These studies showed a statistically high significance between GP (percent germination) and GR (germination rate). In the case of GP, temperatures from 15°C to 35°C showed no significant difference. According to the authors, this means that the temperature range of 15–35°C is better than 40°C for seed germination [16].

2. Methods

The natural angle of inclination of granular loose seeds is one of the important indicators in the calculation of structural elements related to these seeds (container capacity and hopper angle). The researcher [17] described the method for determining the natural angle of inclination of seeds in his scientific work as follows: He measured cotton seeds of different moisture content with a protractor with an accuracy of 30 minutes (Fig. 6.). Seeds of different humidity are scattered into a hill up to 1 m high and the angle of inclination is measured with a 10-fold repetition in different places. Using this method, we also determined the natural angle of inclination of the studied onion seeds (Fig. 7).

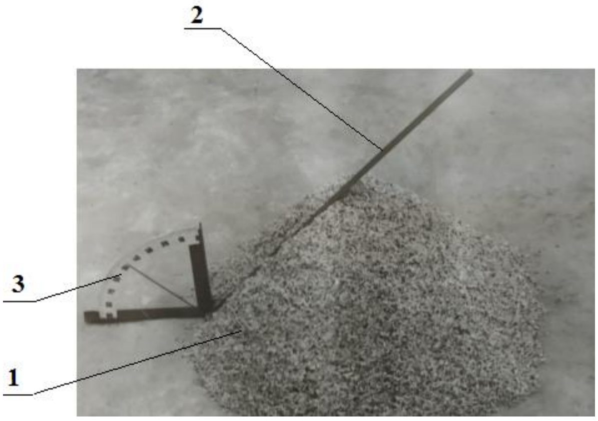


Fig. 6. Determining the natural slope angle of cotton seeds [17]

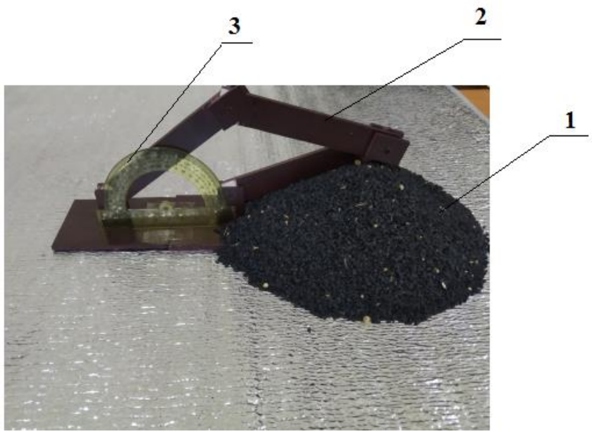


Fig. 7. Determining the natural slope angle of onion seeds

As a result of measurements, it was found that the natural angle of inclination of dry onion seeds is 21÷22^0.

Table 1. Determination of the flotation mass of onion seeds

№	m_{com} (g)	m_{noflot} (g)	m_{flot} (g)
1	100	82	18
2	100	84	16
3	100	83	17

$$m_{mean.v} = \frac{18+16+17}{3} = 17\ g \tag{1}$$

The figure below (Fig. 8) shows the square method of dividing seeds into equal parts, and it is convenient to use this method when repeating experiments many times. Then the process of sorting onion seeds by the flotation method is given in the picture (Fig. 9). Here: *a*) the first stage; *b*) the second stage; *c*) the third stage.

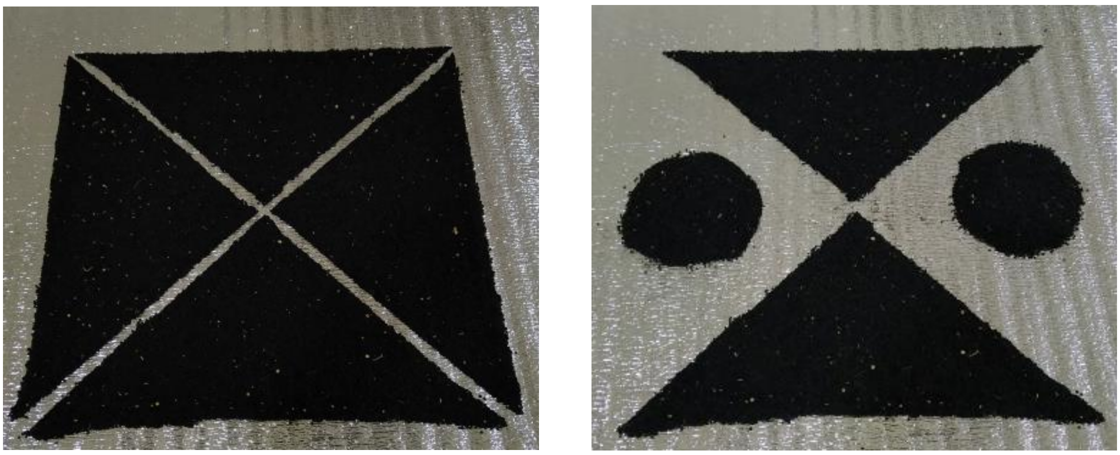
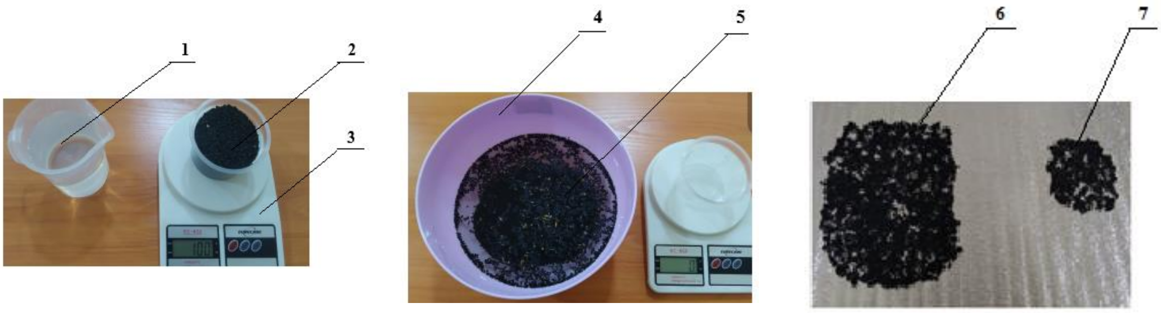


Fig. 8. Square method of dividing seeds into equal parts

When conducting experiments related to electrotechnological processes, it is necessary to use a variety of contact connections. The resistance of contact connections was determined by electrical measurements on a specially assembled experimental stand (Fig. 10). In this case, the contact surfaces were washed with water with different pH - hydrogen index and the contact resistance were measured. The process of determining the pH of water is described in the picture below (Fig. 11). Types of contact connections and issues of their adjustment are also considered in the article [18].



a *b* *c*

Fig. 9. The process of sorting onion seeds by the flotation method. *a*) the first stage; *b*) the second stage; *c)* the third stage; 1 – water; 2 – onion seeds; 3 – electronic scales; 4 – plastic container; 5 – the process of flotation of onion seeds; 6 – seeds that have sunk (sorted) to the bottom of the container; 7 – seeds isolated by flotation

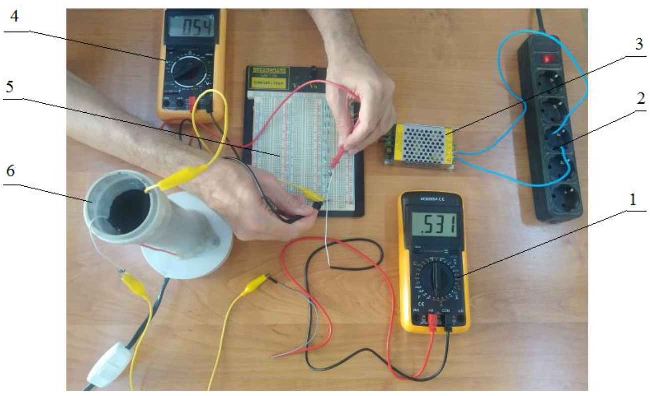


Fig. 10. Electrical measurements were carried out on a specially assembled experimental stand. 1 - ammeter (DT9205A); 2 - power supply (220 V); 3 – AC converter (~220/12 V); 4 - voltmeter (DT9205A); 5 - resistor voltage divider; 6 - tested contact electrodes

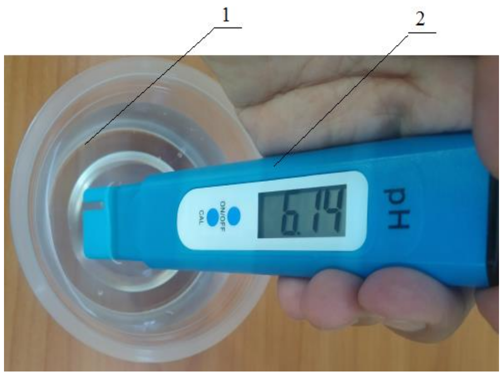


Fig. 11. The process of determining the pH of water. 1 – water; 2 – pH meter

3. Results and Discussion

Results of experiments and calculations to determine the filling factor of a cubic vessel (for onion seeds).

Table 2. The results of determining the coefficient of filling of cubic containers

№	$V_{container}$ (cm^3)	V_{water} (cm^3)	V_{seeds} (cm^3)
1	125	50	75
2	125	52	73
3	125	51	74

$$V_{water.aver.} = \frac{V_{water1}+V_{water2}+V_{water3}}{n} = \frac{50+52+51}{3} = 51\ cm^3 \quad (2)$$

The problems of filling a volume with periodic spherical dispersed particles of the same radius were studied by the authors as a mathematical model [19]. The study of the calculation model and the detection of errors when filling containers of various shapes with fine-grained cotton seeds are considered in the article [20]. Here, the authors note the possibility of optimal design of various vessel shapes using mathematical and geometric models of bodies.

$$V_{com} = V_{onion} + V_{water} = 125\ cm^3 \quad (3)$$

$$V_{water} = \frac{m_{water}}{\rho_{water}} = \frac{51\cdot 10^{-3} kg}{1000\frac{kg}{m^3}} = 51\ cm^3 \quad (4)$$

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$$V_{onion} = V_{com} - V_{water} = 125 - 51 = 74\ cm^3 \quad (5)$$

$$K_{the\ filling} = \frac{V_{onion}}{V_{com}} = \frac{74\ cm^3}{125\ cm^3} \qquad K_{the\ filling} = 0{,}592 \quad (6)$$

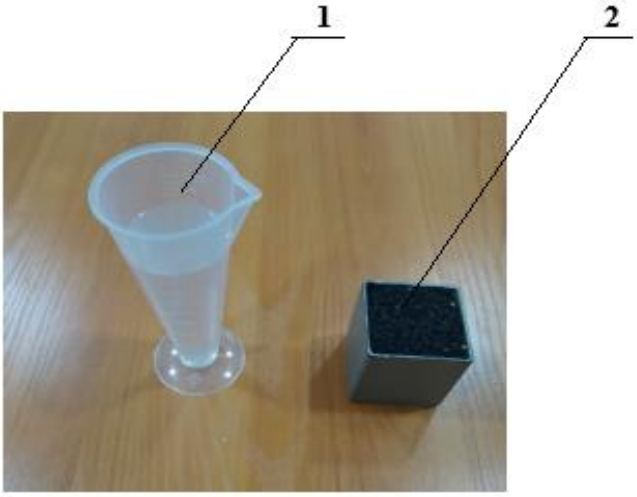
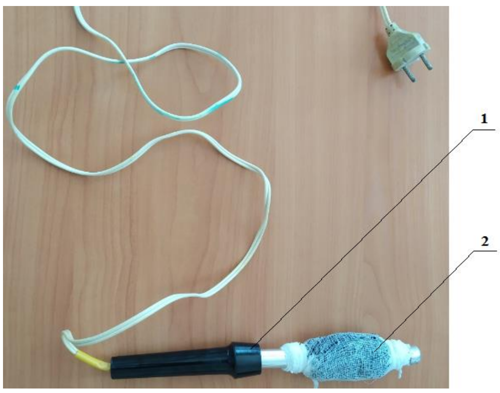


Fig. 12. Determination of masses and volumes. 1 - a special container for measuring water (volume 100 ml); 2 - a metal cube filled with onion seeds (volume 125 cm^3)

Based on the obtained results, mathematical calculations were performed. At the same time, the filling factor was determined (for onions). In the course of the above experiments, for the purpose of clarification, the amount of water absorbed by onion seeds during a single soak was measured. To do this, we measured the mass of dry onion seeds placed in a container with a volume of 125 cm^3 (dry = 53 g).



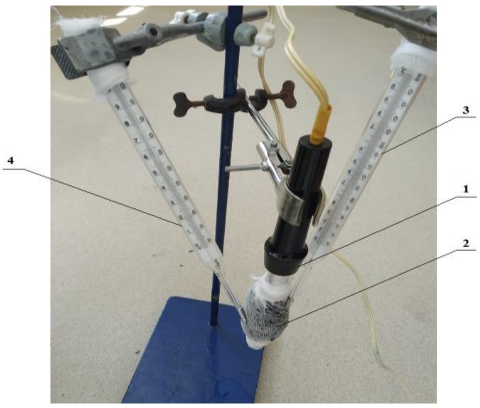


Fig. 13. The course of experiments on measuring the heating of the coating: *a*) electric heater “Ployka”; *b*) experience in temperature measurement. 1 - electric heater; 2 - a wrapper consisting of layers of onion seeds wrapped in gauze. 3 - mercury thermometer T2 (300 ^{0}C); 4 - mercury thermometer T1 (100 ^{0}C)

For soaking in a special container with a volume of 100 ml, 80 ml of water was measured, then a cube filled with onion seeds was poured with water from a special container and the mass of excess water was measured. At the end of the measurements, the mixture in the cube was divided into soaked onion seeds (67 g) and filtered water (51 g) using a special sieve (1x1x0.3 mm in size). The difference between the mass of once soaked and dry onion seeds was:

$$\Delta m = m_{soaked} - m_{dry} = 14\ g. \quad (7)$$

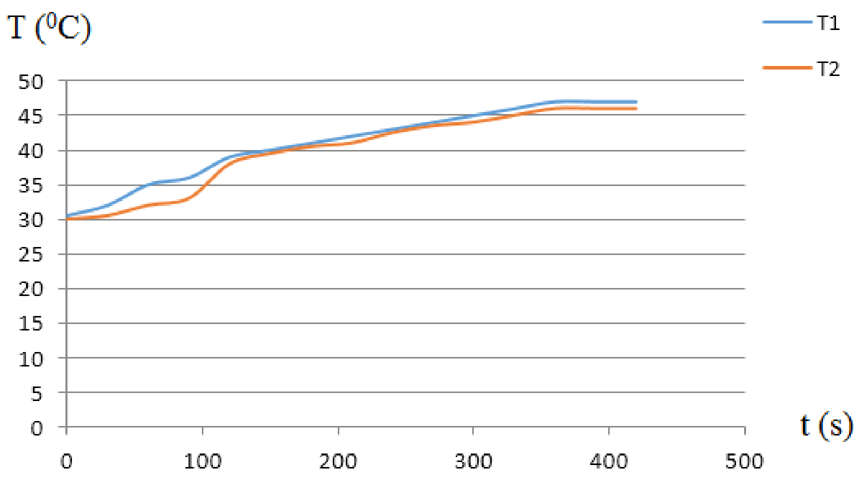


Fig. 14. Temperature versus time graph

The algorithm for calculating the heating of the coating according to the method corresponding to the experimental equipment:

1) Tube length L, m

$$L=0,145 \text{ m}$$

2) Pipe diameter without outer coating (or inner diameter of coating) d_{inner}, mm

$$d_{inner}=20 \text{ mm}$$

3) Coating outer diameter d_{outer}, mm

$$d_{outer}=30 \text{ mm}$$

4) The heating temperature of the electric heater "Ployka" T_{inner}, ^{0}C

$$T_{inner}=100\ ^0\text{C}$$

5) Ambient temperature during the experiment T_{outer}, ^{0}C

$$T_{outer}=29\ ^0\text{C}$$

6) Linear thermal resistance of heat transfer from the surface of the outer surface of the object wall with a layered coating consisting of soaked onion seeds, R_{outer}, m·°C/W

$$R_{outer}=0,4 \text{ m } ^0\text{C/W}$$

7) Additional loss factor, taking into account heat losses, due to the presence of fasteners and supports due to heat-conducting additives in layered coatings consisting of soaked onion seeds, K.

$$K=1,1$$

8) The coefficient of thermal conductivity of the studied layer λ, W/m·°C;

$$\lambda=0,12 \text{ W/m}\cdot{}^\circ\text{C}.$$

Estimated tube heat loss (or heat capacity released on the surface of the soaked onion seed coating layer)

$$\Delta Q = 12,08 \text{ W}$$

4. Conclusions

Uzbekistan is one of the world's leading onion growing countries. Analysis of a priori data shows that as a result of various electrophysical and magnetic effects on onion seeds, positive changes were observed, such as seed health, rapid germination, increased moisture content of young seedlings, and lengthening of root fibers. Many existing methods for determining the parameters of granular scattering bodies, in particular plant seeds, have been analyzed, and primary experiments have been carried out on onion seeds. A new electrotechnological method is recommended, which consists in treating soaked onion seeds with electric current, and then soaking the treated seeds with activated water for a certain period of time. Preliminary results obtained by the recommended method are presented in the form of tables, graphs and engineering calculations. In particular, as a result of studies conducted with onion seeds of the "Andijon qoratol" variety, the filling factor of the container with onion seeds was 0.592, the mass of 100 g of dry onion seeds after a single soaking with water increased to 14 g and amounted to 114 g, in preliminary experiments with an electric heater, the thermal power on the surface coverage of soaked onion seeds with a thickness of 5 mm was 12.08 W.

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