Study on electric pulse destruction of diseased nematodes

To cite this article: N T Tashpulatov and R A Zakhidov 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **939** 012013

Study on electric pulse destruction of diseased nematodes

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Abstract. The article presents the results of research on the use of electric discharges of current for the destruction of worms, larvae and galls of pathogenic nematodes. Nematodes consisting of round worms in the process of their vital activity penetrates the roots, stems and leaves of the plant, disrupting the integrity of tissues, cells and cellular structures, feeding on plant sap leads to lagging behind growth and development, contributes to the spread of various diseases, causes rot and infection. They can be found even in fruits and seeds of plants. Most often, worms form a kind of swelling growth in the roots, in the stems in the leaves and in the fruits, the growths of which are called galls. When unfavorable conditions arise, they move at an accelerated rate in the soil, maintaining their vitality. Therefore, their destruction using well-known methods such as agro technical, thermal biological, chemical, etc. is laborious and ineffective. The article describes an alternative electro technological method for the destruction of nematodes using electric current discharges, which provides the required destruction effect at the lowest cost.

1. Introduction

Known electrotechnological method for the destruction of pathogens that damage the root system of plants [1-3].

These methods are aimed at destroying parasitic worms and gall nematodes that destroy the root system of crops of cucumbers, tomatoes, potatoes and other plants. In the course of their vital activity, nematodes penetrate into the roots of the plant and violate the integrity of the plant, cause rot and infection with various infections. Round worms can be found even in fruits and seeds of plants. Most often, the worms form a kind of swelling growths in the roots, in the stems in the leaves and in the fruits, growths - galls, which gave the name to this type of parasite (Figure 1).

After penetration into the root system, into the stem, leaves or fruits of the plant, the larvae of the nematode feeds on plant sap and form swelling-galls.

As far as location, nematodes are divided into root, stem, leaf and fruit.

Root nematodes from the soil penetrating into the root system of the plant form galls consisting of larvae and a cyst (egg sac) from the eggs of the future generation (Figure 2). Subsequently, galls and cysts feeding on plant sap leads to disruption of water supply and the flow of nutrients from the root system to the stem, leaves and fruits of plants [4-7].

Affected plants lag behind in growth and development, curvature of stems, shortening of internodes, thickening of petioles, drying of buds, and leaf fall occur. Parasites are capable of transmitting various bacterioses and viral diseases, for example, tomato ring spot virus, leaf curly virus and many others.

Leaf nematodes mainly affect the aboveground organs of strawberries and chrysanthemums, penetrating through stomata and small lesions into plants. These nematodes can parasitize inside or outside on the leaves, buds or rudiments of the reproductive organs (Figure 3).

Figure 1. Location of nematode galls in the plant root system

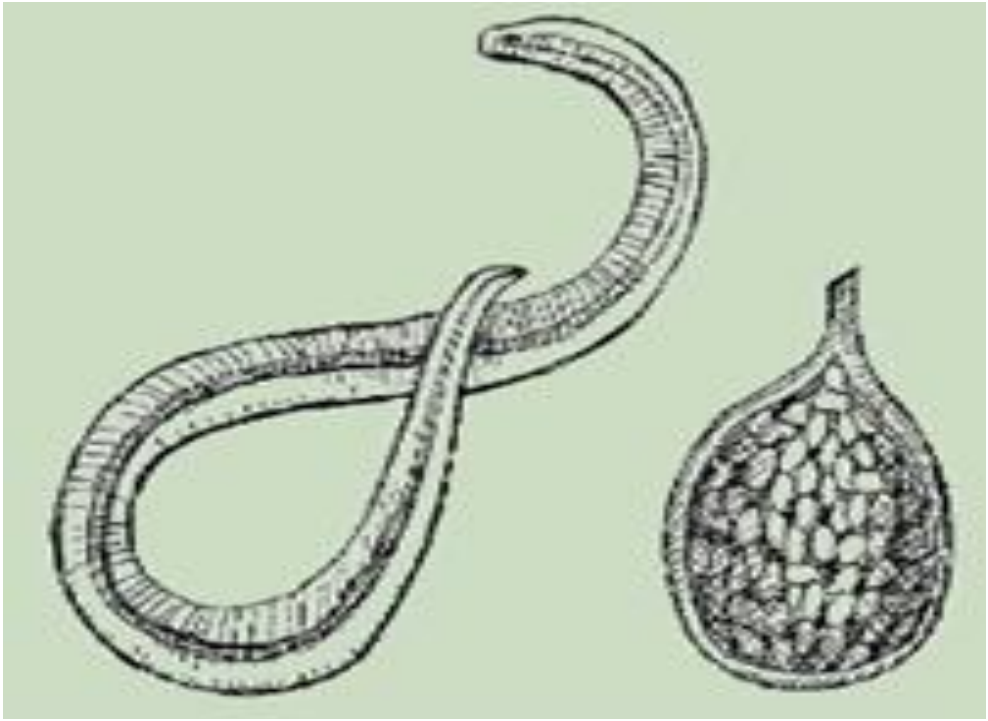

Figure 2. Larva and cyst of nematodes

Figure 3. Location of the nematode in the plates, petioles and veins of plant leaves

Stem nematodes seriously harm flower crops such as: begonias, carnations, tulips, phlox, hyacinths; as well as vegetables and greens: onion, garlic, tomato, cucumber, parsley (Figure 4).

Figure 4. Onion affected by stem nematode

Parasites damage aboveground organs, rhizomes and bulbs. They are especially dangerous for lily bulbs during storage. On the cross section of the affected bulbs, you can see areas of grayish brown color. When stored in conditions of high humidity and temperature, nematodes cause rotting of the bulbs. In daffodils, they are the cause of bulb ring disease. On tulips, nematodes can cause yellowish or brownish stripes and spots on the outer scales [7, 8].

Disease from nematodes is classified as melodyynosis. It is difficult to identify infection with nematodes at the initial stage of plant development, which is associated with the following factors: the parasite has a microscopic size - 0.2-1.2 mm; lays over 2000 eggs; can reproduce up to 13 generations per year; the female can go without food for about one year. Resistance to low temperatures - up to 30 degrees of frost, and aggressive external conditions is another advantageous feature that makes it more difficult to fight this parasite.

One of the features of parasitic nematodes is the accelerated reproduction by larvae and spores, as well as the movement of larvae and adults at a rapid pace in the soil in search of nutrients. Worms (adults and larvae) of nematodes, when the soil freezes in winter colds or when the soil is strongly heated in summer, can rush at a rapid pace into the depth of the soil up to 90 cm. They are resistant to rising and falling temperatures. This testifies to their resistance to the actions of unfavorable external factors.

At present, agrotechnical, thermal, biological and chemical methods are used to kill worms and nematode larvae.

The agrotechnical method based on the use of crop rotations, replacement of contaminated soil, the use of treated and treated seedlings is not very effective due to the fact that the infection of the plant occurs after the growth and development of the plant, i.e. after blooming of roots, stems and leaves.

With the thermal method, after detection, plants infected with worms are carefully dug up and removed from the site and burned. To exclude the spread in a diameter of 1 m, bushes of tomatoes, cucumbers and other plants are removed. The soil is treated with boiling water. The process is laborious, expensive and ineffective [8, 9].

The biological method is based on the use of mycelium of fungal pathogens, drugs that cause paralysis of nematode larvae and worms, followed by the destruction of parasites. The method has low efficiency due to the complexity of its application and selectivity to nematodes.

At present, mainly a chemical method based on the use of poisonous chemicals Nemoval and Nematocid is used to kill worms and nematode larvae.

To achieve the desired effect with the drugs Nemoval or Nematocid, it is recommended to monthly treatment of each plant bush during the growing season, which is a laborious and capital-intensive process.

In addition, the use of chemicals in high doses and on a large scale in open and closed ground, due to poor control, has now led to serious negative consequences. For example, the prolonged introduction of chemicals into the soil where vegetables, melons and gourds are grown, leads to a concentration in a large amount of pesticides in the fruits of vegetables, melons and vegetable organisms of useful plants, and when used, there is a direct toxic effect on the human body.

They cause severe poisoning, premature aging, the appearance of malignant tumors, hereditary diseases. Beneficial microorganisms in the soil especially suffer from pesticides.

In addition, soil treatment with chemicals in order to destroy parasitic nematodes today does not provide sufficient efficiency due to the ability to develop immunity and get used to pesticides; the ability to rapidly migrate pests when a harmful factor occurs; the ability to stage hatching of eggs and the appearance of larvae after weakening the negative effect of the poison of chemical preparations, the effect of pesticides on the skin of worms, followed by the initiation of respiratory inhibition; the need for repeated treatment with different chemicals associated with additional financial and labor costs [10, 11].

To achieve effective destruction of nematodes, we studied the most characteristic features of the physiology and biology of harmful individuals.

Gall nematodes can give from 1 to 13 generations per year. The larvae of nematodes, leaving the egg, look for the host plant and penetrate its roots, where they begin to feed. The optimal conditions for the development of the pest are moderate soil moisture (40-60%) and temperatures in the range of 20-30 ° C. Over time, young nematodes transform into immobile females and males capable of moving.

The development of root-knot nematodes in the greenhouse is in most cases a classic parthenogenetic cycle. Males are rare and do not take part in breeding. Their lifespan is 3-5 weeks. The reproductive period of the female lasts 2-3 months, during which time she is able to lay up to 2500 eggs. It forms an egg sac on the surface of the root from a gelatinous secreted substance. It takes 24-28 days for the development of one generation [4, 12, 13].
The second larval stage is resistant to unfavorable environmental conditions (cryptobiological stage) and can remain virulent for up to 6-12 months. The temperature range at which the invasive larva of gall nematodes is able to exhibit activity is within 5 - 40 ° C.
In greenhouses (greenhouses), root gall nematodes can develop in one of two types of life cycles. The first type is observed in the initial period of colonization of plants and is characterized by the obligatory migration of the invasive larva from the egg sac into the soil, followed by the defeat of a new root site or a new host plant. The second type of life cycle involves a short migration along the root conduction system and the transformation of larvae into oviparous females without entering the soil.
The parasite's weight cycle takes place in the tissue of the host plant. All larval stages and adults are invasive. Crypto biological, that is, to survive unfavorable conditions, is the fourth larval stage, which can survive in the external environment from six months to a year.

2. Methods
In order to increase the efficiency of the destruction of pathogenic parasitic nematodes with an electric pulse method, the biological structure and physiological development of nematodes in the roots and rhizomes of cucumbers were studied as a factor of most importance.
It was taken into account that all types of parasitic nematodes in the initial stage, being in the soil, mainly infect the root system of cucumbers and then, under favorable environmental conditions, gradually pass into the rhizomes, stem and other parts of the plant.
The maximum accumulation of parasitic nematodes occurs at the end of the growing season, i.e. before removing plant residues from cultivated areas. In this process, one of the main factors is the full-scale removal of infected cucumber plants and their debris in place with galls, larvae and worms of parasitic nematodes. However, this process is the most time consuming and almost impossible to carry out. So, after the introduction of parasitic nematodes, the root system of cucumbers lags behind growth and development and becomes fragile. At the slightest physical effort, when pulled out or separated from the soil, it breaks off and remains in it.
Therefore, to achieve maximum efficiency, the destruction of the nematode family must be processed without destroying the stems and root system, rapidly (0.01 ... 0.5 seconds) and three times [1, 2, 13, 14].
The problem is solved by the fact that the method of electro-pulse treatment of plants includes passing a high voltage electric current through the plant to the soil by simultaneously touching with three electrodes to the stem (lash) of cucumbers, the processing is carried out with a high voltage of 4-6 kV for 0.4-0.5 s, with a discharge energy of 0.025-0.027 J and a discharge current of 0.04-0.05 A by passing an electric current from the upper tiers of the plant stem to the soil by touching the electrodes to different levels of the cucumber stem [13, 14].
An increase in the efficiency of destruction of pathogenic nematodes and cucumbers is achieved due to the fact that the treatment is carried out with a high voltage of 6 kV for 0.4-0.5 seconds. with a discharge energy of 0.027 J with a discharge current of 0.05 A by passing an electric current from the upper levels of the plant stem to the soil by touching with a three-electrode system of different power and charge polarity.
The scheme of treatment with electric pulse current discharges of infected plants with galls and nematode larvae is shown in Figure 5.
The circuit consists of a power source - 1, connected to flexible copper conductors by a high-voltage pulse discharge converter - 2, positive and negative discharge electrodes - 5 and 6, connected to by means of high-voltage electrical cables - 3 and 4, a grounding electrical conductor - 14, grounding terminals - 7 and grounding electrode - 8.
Positive and negative electrodes - 5, 6, when working, touch the plant stems at different levels and form a chain consisting of a plant stem - 9, the root system of a plant with parasitic nematodes - 10 and 11, soil with

nematodes - 12 and a ground electrode - 11 and an electric cable - 13 through which the passage of high-voltage electric current is ensured.

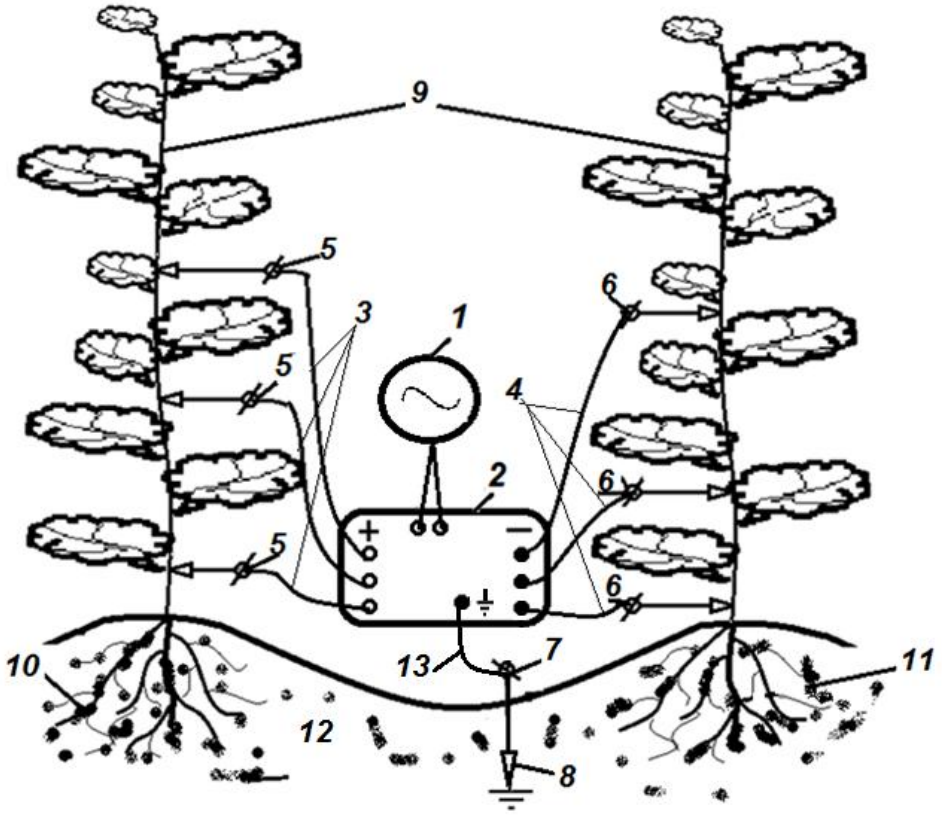

Figure 5. 1 - power supply; 2 - converter of high-voltage pulse discharges; 3 and 4 - high voltage electrical cables; 5 - positive discharge electrodes, 6 - negative discharge electrodes; 7 - terminal of the grounding electrode; 8 - grounding electrode; 9 - infected cucumber stalk; 10 - rhizomes with galami and nematode cysts; 11 - worms, nematode larvae; 12 - soil; 13 - grounding electrical conductor

3. Results and Discussion

The method of processing a plant is carried out as follows. The height of touching the upper electrodes on the plant stems is chosen - 45-50 cm from the soil level. The touching height of the middle and lower electrodes is selected at a distance of 30 and 15 cm from the soil level. The high voltage output voltage is set to 6 kV. The processing time is set at 0.4-0.5 s. The discharge current is vibrated 0.002-0.05 A. The grounding electrode 8 is installed in the soil 12 between the bushes of the plant 9 to a depth of 30 cm from the surface of the earth. When you turn on the converter of electrical impulse discharges 2 and alternately touch the electrodes of the positive and orticate charge 5 and 6 of all three phases on different areas of the plant stem 9, it creates a burning effect of nematodes located on the surface of the tissues (stem and leaves) of the plant, as well as a microhydraulic shock in the inner part of the plant intracellular electrohydraulic shock which leads to rupture of cell membranes of nematode parasites. Tears and microcracks in the cell membranes of worms, larvae and the outer membrane of cysts (ovary) and nematode galls located in the plant, in the outer surface of the root system and located in the soil at a close distance from the root system of the plant, is fatal [1, 2, 13, 14].

The destruction of parasitic nematodes in the soil 12 occurs due to the formation of high intensity and electric field and the passage of a pulsed-bursting current between the grounding electrode 8, the root system 10, worms, larvae of nematodes 11. In this case, the stem of the plant 9 with healthy tissues, the fruits receive a short-term electrophysical a discharge that stimulates plants to enhance growth and development.

The research results showed that during the electric pulse treatment of infected plants, the pulsed discharge currents with a certain voltage level value mainly pass through cysts with a liquid-filled structure (having the lowest electrical resistance), living tissues of larvae and worms that have a large number of microelements in their bodies, an ion-containing liquid structure. At the same time, parasitic nematodes invading the plant organism leads to the selection of a large amount of plant sap, as a result of which there is a lack of moisture and microelements in the plant tissues. A decrease in moisture in the plant body also leads to an increase in the electrical resistance of the plant tissue, which subsequently prevents the passage of electric current and the destruction of the cellular structure of the plant. Therefore, the damaging effect of the current is achieved by passing it mainly through the infected areas of plant tissue where the greatest number of individuals of parasitic nematodes is accumulated.

A further increase in voltage and processing time leads to the passage of current over the surface of the plant tissue, which leads to an increase in the energy intensity of the process.

The results of the research have established that, at a voltage of 6 kV, with a discharge current of up to 0.5 A, with treatment in a time interval of up to 0.5 s at an energy consumption of 0.027 J, up to 90% within a radius of 90 cm of soil around the root system of the plant.

The method of treating plants infected with a parasitic nematode with electrical impulse discharges is carried out by us, a special installation for electrical impulse processing of plants.

The installation works as follows: the positive electrode is connected to the root collar of the plant, and the negative electrode is embedded in the soil. After connecting the positive electrode with the root collar of the plant, a chain is formed consisting of: positive electrode + root system infected by larvae and adult individuals of nematodes + infected soil with larvae of viruses and pathogens + negative (grounding) electrode, through which a pulsed current with a high tension.

The currents of pulsed discharges lead to strong irritation of the membranes of plant cells of tissues and the outer envelopes of nematode viruses, which lead to the destruction of tissues of the root system and rupture of membranes of nematode larvae, accompanied by a massive defeat of viruses. The above method of processing plants was carried out before harvesting plant residues on the experimental site of the central greenhouse of the Yunusabad district of the city of Tashkent.

The results of research on electrical pulse processing of cucumbers variety "Multitar" are shown in Table 1.

To carry out the experiment and obtain reliable information about the observed plants and the results of the research, the greenhouse land plot was divided using dielectric shields into 8 plots with a size of 3 × 1.0 m with plants of 10 bushes.

After that, an electric pulse treatment of the infected plants of each site with different levels of discharge voltage Up, (from 1.0 to 7.0) kV was carried out with a processing time $\tau p = 0.04 \ldots 0.5$ s, a discharge current Ip = 0.03-0,05 (Table 1).

Within 3 days, the soil was prepared for new crops. On the 4th day, new seedlings of "Multitar" cucumbers were planted with the same degrees of development. During the entire growing season, the plants in the treated areas were monitored.

In plots No. 5, No. 6, and No. 7, in comparison with the control, there was good growth and development of plants and a high yield was obtained.

In plots: No. 1, No. 2, No. 3, No. 4 and No. 8, on the contrary, the yield decreased. This is due to the fact that when processing with a discharge voltage from 1.0 kV to 4.0 kV, it is impossible to achieve the full-scale lethal effect of nematodes.

When processing plants with a voltage of Up = 7.0 kV and higher, the passage of a discharge current through the peel (bark) of plants was observed, which is explained by the low susceptibility of pests found in plant tissues, fire and nematode cysts.

Table 1. Results of electrical treatment of cucumbers variety "Multitar"

No. plots	Processing objects	Discharge voltage level - U_p, kV	Discharge current - I_p, A	Processing time - τ_p, s	Effect of defeat,%	Productivity, kg /%
1	10 bushes, (control)	0	0	0	0	4 / 0
2	10 bushes	1.0	0.03-0.05	0.4…0.5	28	4.3 / 43
3	10 bushes	2.0	0.03-0.05	0.4…0.5	37	4.7 / 47
4	10 bushes	3.0	0.03-0.05	0.4…0.5	62	5.5 / 55
5	10 bushes	4.0	0.03-0.05	0.4…0.5	73	6.8 / 68
6	10 bushes	5.0	0.03-0.05	0.4…0.5	85	7.8 / 78
7	10 bushes	6.0	0.03-0.05	0.4…0.5	92	9.1 / 91
8	10 bushes	7.0	0.03-0.05	0.4…0.5	45	5.1 / 51

With the following optimal parameters: the level of the discharge voltage Up = 4 ... 6 kV and the duration of the current flow τp = 0.4 ... 0.5 s, the discharge current vibrates 0.002 ... 0.05 A, the discharge energy Wc = 0.025 ... 0.027 J, 90 % susceptibility of nematode galls in infected plants [1, 2].
Thus, experimental studies have shown the high efficiency of electric pulse treatment in the destruction of worms, cysts and galls of pathogenic nematodes.

4. Conclusions

1. The research results showed that the use of electric current makes it possible to completely destroy nematodes in all phases of its growth and development.
2. For best results, treatment of infected plants with nematodes should be done before harvesting the stems and rhizomes of plants or at the stage of the greatest infection.
3. Electric pulse treatment leads to the enrichment of soil with microelements and humus due to broken undissolved microelements, acceleration of the decomposition of plant residues and nutrient sap accumulated by nematodes.

References

[1] Tashpulatov NT, Bayzakov TM 1996 Method of cleaning plants, A.S. No. 3456 certificate 504 registered in the state register of inventions, industrial designs and utility models of the Republic of Uzbekistan.
[2] Tashpulatov NT, Bazarov E, Tashpulatov J 2003 Method of electro-pulse treatment of plants, Patent UZ IAP 02758, 02 04 2003.
[3] Isakov A, Rakhmatov A, Ismailova Z 2020 Study the effect of the discharge electrodes on the characteristics of the corona discharge *IOP Conf. Ser.: Earth Environ. Sci.* **614** 012011.
[4] Doshi RA, King RL, Lawrence GW 2010 Classification of Rotylenchulus reniformis Numbers in Cotton Using Remotely Sensed Hyperspectral Data on Self-Organizing Maps *Journal of nematology* **42**(3) 179–193.
[5] Dryzer M, Niven C, Wolter S, Arena Ch, Ngaboyamahina E, Parker Ch, Stoner B 2019 Destruction of Nematode Ova in Wastewater using Electroporation *Biophysical Journal* **116**(3) 217a.
[6] Singh V, Sharma N, Singh Sh 2020 A review of imaging techniques for plant disease detection *Artificial Intelligence in Agriculture* **4** 229-242.
[7] Ferentinos KP 2018 Deep learning models for plant disease detection and diagnosis *Comput. Electron. Agric.* **145** 311-318
[8] Golhani K, Balasundaram SK, Vadamalai G, Pradhan B 2018 A review of neural netwoks in plant disease detection using hyperspectral data *Inform. Proc. Agric.* **5**(3) 354-371.
[9] Kamilaris A, Prenafeta-Boldú FX 2018 Deep learning in agriculture, a survey *Comput. Electron.*

Agric. **147** 70-90.
[10] Toshpulatov NT**,** Tursunov O, Kodirov D, Kholmuratova G 2020 Environmentally friendly technology for the destruction of tobacco mosaic viruses (TMV) from selected species of plants *IOP Conf. Series: Earth and Environmental Science* **614** 012133.
[11] Mahlein AK, Rumpf T, Welke P, Dehne H-W, Plumer L, Steiner U, Oerke E-C 2013 Developments of spectral indices for detecting and identifying plant diseases *Remote Sens. Environ*. **128**(21) 21-30.
[12] Martinelli F, Scalenghe R, Davino S, Panno S, Scuderi G, Ruisi P, Villa P, Stroppiana D, MircoBoschtti L, Goulart R, Davis CE, Dandekar AM 2015 Advanced methods of plant disease detection *Agron. Sustain. Dev.* **35**(1) 1-25.
[13] Sankaran S, Mishra A, Ehsani R, Davis C 2010 A review of advance techniques for detecting plant diseases *Comput. Electron. Agric*. **72**(1) 1-13.
[14] Toshpulatov NT 2020 The mechanism of destruction of plant rhizomes under the influence of an electric pulse discharge *IOP Conf. Series: Earth and Environmental Science* **614** 012115.
[15] Toshpulatov NT 2020 Theoretical basis for the movement of a pulsed current discharge through a plant organism *IOP Conf. Series: Earth and Environmental Science* **614** 012009.