Enhancing the efficiency of cold water-soluble fertilizers through electrohydraulic technology

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Abstract. This article discusses the improvement of the efficiency of cold water-soluble fertilizers through the use of electrohydraulic technology to facilitate the assimilation of nutrients in plants. The issue of enhancing the efficiency of fertilizing plants through electrohydrolysis using cold water-soluble organic and mineral nutrients is examined. According to the detailed results of nutrient assimilation technologies in plants, the amount of nutrients absorbed by plants constitutes 30-40% of the fertilizer. To enhance the efficiency of nutrient assimilation in plants, it is necessary to break down the nutrients in the cold water-soluble composition into small particles, increase plant absorption capacity, and simultaneously demand the neutralization of bacteria in the cold water-soluble fertilizer composition. By applying the electrohydraulic effect to the cold water-soluble fertilizer, the following parameters were identified for maximum fragmentation of solid particles in the fertilizer composition: discharge voltage of 24 kV, 175 pulses, and a capacitor capacitance of 0.8 μF. This process allows for the fragmentation of solid particles in the fertilizer composition down to 0.002 mm, which is challenging for plants to assimilate on their own. The regime and parameters of electrohydraulic treatment, ensuring the fragmentation of solid particles in cold water-soluble fertilizers down to 0.002 mm, were determined, and this can increase the efficiency of the fertilizer for plant growth by 33-37 qq.

1. Introduction

In the world, each era has set special tasks for the further development of all sectors of the national economy, especially agriculture. In order to successfully solve this huge task, on the basis of the comprehensive improvement of the quality of work in all areas of agriculture, at a time when it is required to meet the needs of the population for food products, raw materials for industry, and fodder for livestock, to increase the productivity of the soil, effective use of mineral and organic fertilizers, placement of crop types, increase of productivity is one of the main activities [1].

Due to the rapid growth of the world's population, the rapid development of industry, the deterioration of the environmental condition of the planet as a result of global climate change, and the limitation of natural resources such as land and water resources, human needs for food and agricultural products The increasing demand for water is one of the urgent tasks of increasing crop productivity through rational use of land, improvement of land reclamation and fertility.

Only 30-40% of nutrients obtained from organic and mineral fertilizers are absorbed by plants. Today, in the agro-industrial complex, mineral fertilizers are mainly used in dry form in mechanized form. Liquid fertilizers are more effective than dry fertilizers in feeding plants, but they require a lot of money and labor. Breaking down the cellulose and lignin membranes of cells in order to transfer useful organic and mineral substances into a form that is easy for plants, and delivering the necessary useful substances inside them to plants is considered the most important task of increasing the productivity of agricultural products [2].

The amount of some groups of organic compounds in the products of agricultural plants and the quality of the product varies to some extent depending on the biological characteristics of the plant, the variety and growing conditions, and agrotechnics [3].

In order to increase the amount of agricultural crops and improve its structural quality, it is important to properly

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organize the conditions of plant nutrition. For example, increasing nitrogen nutrition of plants increases the size of the main crop and its protein content, while phosphorus-potassium nutrition causes the accumulation of sugar in sugar beets and a lot of starch in potato tubers. Also, phosphorus-potassium fertilizers increase the amount of oil in oil-bearing plants and improve its quality indicators.

So, by creating favorable nutritional conditions for plants with the help of fertilizers, it is possible to increase their yield, the amount of the most necessary organic compounds in dry matter, and quality indicators.

The transfer of nutrients to plants is determined by many factors. Plants can absorb 95 percent or more of CO_2 through leaves, as well as ash elements, sulfur, and nitrogen from aqueous solutions when fed from roots. But the main amount of nitrogen, water and ash elements is transferred to plants from the soil through the root system [4].

Depending on the biological characteristics of the plant and growing conditions, the root system develops at different levels. In nutrient-poor soils and arid regions, plants in search of nutrients and water produce a relatively large root mass.

Fertilizer application usually slightly reduces the ratio of root mass and surface mass, but increases the total amount of these indicators and distribution to the lower layers of the root system. Thus, fertilizing agricultural crops not only increases the mass of the above-ground part of plants, but also has a positive effect on the development of the root system.

The theory of mineral nutrition was confirmed and recognized for the first time in 1858 in an artificial nutrient medium (in water culture), when the plant was grown until full maturity. Later, the plant was grown in a sandy environment (sand culture) in a complete nutrient mixture [5].

The ideas of Dutroche (1837) about the transfer of nutrients to a living cell are noteworthy. He believes that water and substances dissolved in it enter the cell through the pores of the cytoplasmic membrane based on the phenomenon of diffusion.

Sachs believes that this happens through chemical processes based on the phenomenon of cumulative diffusion, in which the concentration of substances inside the cell always equalizes the concentration of the external environment.

Pfeffer, De Vries, Mayer and other scientists were supporters of diffusion osmotic theory. According to this theory, the plant moves nutrients along with water through the root system. Water is always evaporated during transpiration. Thus, the entry of nutrients to the plant directly depends on the intensity of transpiration. However, the information about the rules of entry of nutrients into the plant went beyond the diffusion-osmotic theory [6].

K.A.Timiryazev said that there is no connection between water and nutrients entering the plant: "Plants do not need such a large amount of water that is evaporated by them in the process of nutrition" [7].

Sabinin D.A. and this idea was further developed in his works. In this case, it was proved that substances in low-concentration nutrient solutions are highly concentrated in plant sap [8].

At the end of the 19th century, the lipoid theory was put forward by Overton, according to which the entry of nutrients into the cell occurs as a result of the dissolution of nutrients in the lipid components of the cytoplasmic membrane. They observed a correlation between the rate of entry of basic aniline dyes into the plant cell and the rate of dissolution in lipids [9].

Traube and Ruland, the authors of the ultrafiltration theory, believe that the passage of nutrients through the cytoplasmic membrane depends on the size and molecular size of the cytoplasmic membrane pores. Dravert observed that the penetration of acidic dyes under study into cells depends on the size of their molecules. However, this theory cannot explain the introduction of large-molecule amino acids, phytin and other organic substances into plants.

At the beginning of the 20th century, Devo discovered the possibility of rapid binding of cations contained in strongly diluted solutions to plant cells. This situation led to the emergence and development of the theory of adsorption. Also, it was shown that the cations attached to the cell can be reabsorbed from the cell tissue due to the exchange of mutually equivalent bases. Thus, the absorption of some ions is accompanied by the suppression of other ions, and this process depends on the concentration of substances and time [10].

In many studies of Sabinin D.A. and other scientists, it was shown that the absorption of nutrients depends on the level of cell viability and that the root system has an active role in this process. The amount of substances contained in plant sap depends on the supply of plants with nutrients, as well as on the biological characteristics and age of the plant. Different physiological activity of cells and tissues determines their different chemical composition and different electrical properties.

The level of tissue metabolism also determines the level of absorption of nutrients. Steuerl, Lundegord, Bürström and other scientists found that there is an integral connection between tissue respiration and absorption of mineral salt ions [11].

In Hogland and Broyer's work, the increase in the rate of entry of substances into plant cells and tissues occurs in the following cases that activate respiration: when aeration of the nutrient solution is improved, glucose is added to it, temperature is increased, and other conditions are improved [12].

D.A. Sabinin proved that there is a connection between plant nutrition and the formation and development of certain organs [13].

The following theories were discussed in the above-mentioned summary of studies on mineral nutrition of plants: diffusion - osmatic, lipoid, ultrafiltration, adsorption.

The presented theories have led to the development of views on the process of the transfer of nutrients to plants, and in these theories mineral nutrition has a certain importance. Various aspects of the transfer of elements to plants are practically correct, but very simply and briefly described.

In the following decades, the theory of the transfer of mineral nutrients to plants has developed and advanced, but at present this theory includes some of the points in the previously mentioned rules.

The root is a special part of the plant that keeps the plant firmly in the soil and carries out the function of transferring nutrients, distributes and delivers primary absorbing water and mineral substances to other organs. The root is an organ that performs many biological synthesis processes and a number of other special functions.

The nature and strength of the development of the root system is determined by the plant's ability to absorb nutrients.

In general, the main amount of nutrients is absorbed by young, growing root hairs. Cells in root hairs intensively absorb elements in mineral nutrition compared to other cells.

The root system of field crops has a very large absorption surface. During the flowering period of plants, the root surface develops the most, including the largest amount of active surface. Nutrients absorbed in the growing and pulling part of the roots are quickly used and directed to the upper part of the plant [14].

Nutrition is the exchange of nutrients between the plant and the external environment. These nutrients pass from the soil and air to plant cells, to the composition of complex organic compounds, and are decomposed by the plant and form new substances from it.

Solar energy serves as a source of decomposition and production of organic matter for plants. Aerial nutrition of plants is based on the process of photosynthesis, which absorbs CO2 (carbon dioxide) from the atmosphere and forms organic compounds (carbohydrates) with the help of chlorophyll. The speed of this process depends on the supply of light, heat, moisture, nutrients to the plant and its biological characteristics. In order to ensure sufficient absorption of sunlight by plants, it is necessary to plant them facing the sun, give shape to the trees, and correctly determine the number of plant stems.

So, based on the process of plant nutrition, the combined effect of the factors must be correct for its life. Such conditions are carried out as a result of the flowering of agronomic measures, including the improvement of water and air conditions with soil cultivation, the use of organic and mineral fertilizers, irrigation - land reclamation measures. If the plant is not provided with any factor during the growth period, then the effect of another factor will be weak. If there is a lack of soil moisture, the effectiveness of fertilizers decreases, and as a result of irrigation, this factor has a positive effect. On the other hand, if the soil is too wet, it creates unfavorable conditions due to the lack of oxygen for the roots to breathe. It is known that there is not enough water for plants in arid lands, so there is a need to produce moisture conservation measures in such conditions. In regions with a lack of moisture, it is advisable to apply fertilizers in deep layers or to irrigate, or if not, an opportunity will be created for plants to use well-dissolved nutrients from these layers [15].

If the crop sprouts are sparse, plant nutrition and light area do not allow to fully use the applied fertilizers. Nutrition of plants through the root system, not only to its biological properties, the supply of photosynthesis products, the speed and size of the root system development, soil structure and aeration, moisture, solution reaction, the amount of nutrients and their ratio, the activity of the soil microflora, the root system depends on excreting substances and other factors.

Currently, the efficiency of using chemicals does not fully meet the requirements of agriculture and environmental protection. When mineral fertilizers and biocides are added to the ground in excess of the norm, their main part is absorbed by plants, but the rest of them accumulates in the soil in a form that cannot be absorbed by plants. For example, when 240-250 kg of nitrogen is applied to 1 hectare of cotton, the plant uses only 30-40% of it, and when 120-130 kg of phosphorus is given, 15-20%. The rest accumulates in the soil as nitrate and phosphate salts. They gradually dissolve under the influence of water, add to the wastewater and pollute it. Nitrogen content in the form of nitrates in water is harmful if it is 40-50 mg/l. It was observed that nitrate reaches and accumulates with water in the deep layers of the earth (up to 12 m). According to the data, nitrate accumulation of 900-1200 kg/ at a depth of 15 m of 1 hectare of cotton area was determined. When phosphorus fertilizers are applied to the earth, not only phosphate salts accumulate, but also "heavy metals" accumulate. When 1 ton of superphosphate is added to the ground, 20 mg/copper, 100 mg/zinc, and 300 mg/margamush are accumulated in 1 kg of soil. Biocides accumulate in the soil for several years without decomposition. 80-100% of the biocides applied in the first year remain for the following years, and they can only be spread depending on the depth and sides of the soil. For example, when DDT is sprayed, 80%, 43% of aldrin, and 20% of hex chlorate remain in a 15 cm layer of soil after 2-3 years. As a result of improper use of chemicals over the years, the soil becomes saturated with toxic substances, which spread from the soil through the roots of the plant to all organs

and poison the plant. Toxic chemicals have a negative effect on plants and all other living organisms. Toxic chemicals are present in soil, water, and plants, are transferred to farm animals through plants and plant products, and accumulate in the human body through plant and animal products. As a result of this, various infectious diseases appear, and it even causes mutation and destroys the human race. Therefore, it is important to identify the land where toxic chemicals are accumulated, and to improve them.

2. Solving style

Currently, electrohydraulic processing is of particular importance in feeding plants with local fertilizers. local fertilizer contains a complex of organic substances and is a unique raw material for agricultural industries and the national economy. The organic substances of the local fertilizer and the chemical acids included in its composition increase the fertility of the soil, which are sources of physiologically active substances that enhance the vital processes of living organisms. However, these properties are manifested only after appropriate decomposition processes of organic fertilizer and a number of its compounds have passed into a state available for assimilation by plants. In the natural state, this process takes place very slowly, so it is ineffective to use local fertilizer in its pure form. To use animal manure as a fertilizer, various methods of activating organic substances and nitrogen in manure are used: thermal, chemical and biological methods [16].

Electrohydraulic treatment has a multifactorial physicochemical effect on complex organic structures and is a promising method of its activation.

4. Results and Discussion

The main problem during irrigation of agricultural crops with local fertilizer juice is to create a nutrient solution with certain parameters. Chemical elements dissolve in water, they participate in the nutrition of plants due to their absorption through the root system. Depending on the stage of plant growth, different nutrients are required, but local fertilizers must be recycled when used.

Evaluating the effectiveness of electrohydraulic treatment of liquid feed and its degree of decomposition is taken as a factor indicating the condition of the processed product [9].

A number of experiments were conducted to study the influence of each factor of electrohydraulic treatment on the degree of decomposition of nutrients in water. Based on the results of the experiments, the following connection graphs were constructed."

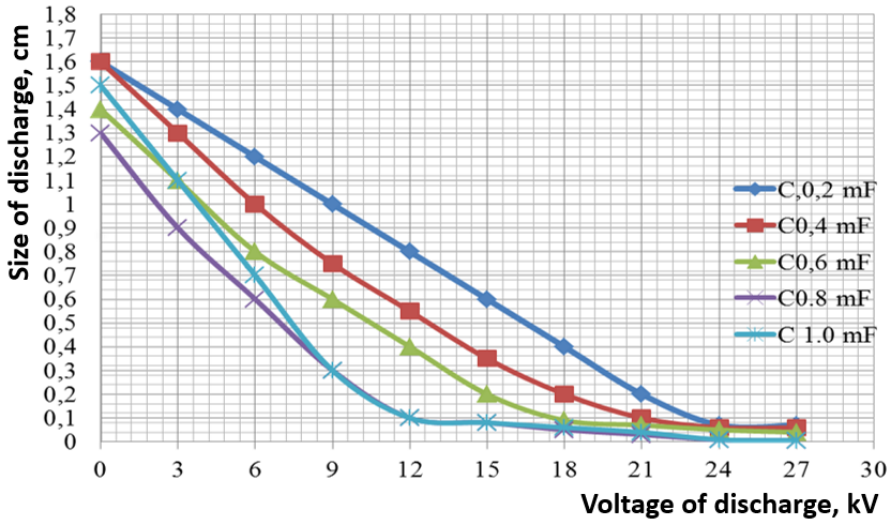


Fig. 1. In the application of the electrohydraulic effect, the disintegration of solid particles in the water composition is contingent upon the discharge voltage

This was determined from the analysis of the curves in the given graph. When the liquid feed is treated with electrohydraulic effect, the discharge voltage increase to 24 kV breaks the large feed elements in the water down to 0.005 cm (Figure 1). The damage effect does not change as the discharge continues to increase the voltage. It only leads to an increase in energy consumption.

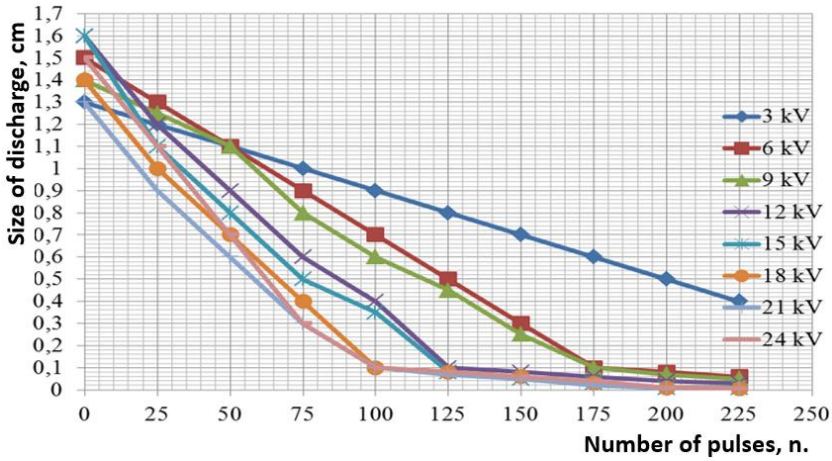


Fig. 2. In the application of the electrohydraulic effect, the disintegration of solid particles in the water composition is influenced by the number of pulses

From the conducted experimental studies, it is shown that in the treatment of liquid solution with the electrohydraulic effect, as the number of pulses increases, the fragmentation of large particles increases sharply. When the number of pulses exceeds 18-20 units, the level of damage becomes constant. Increasing the number of pulses from 200-225 pieces does not affect the level of decomposition of nutrients (Figure 2).

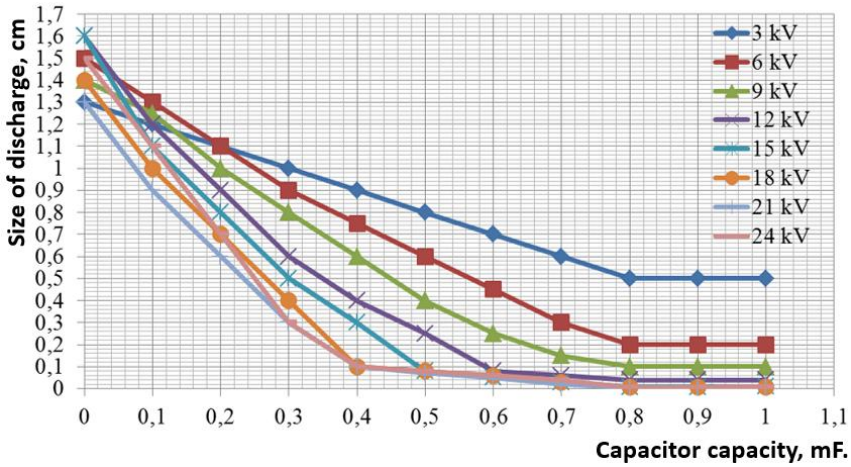
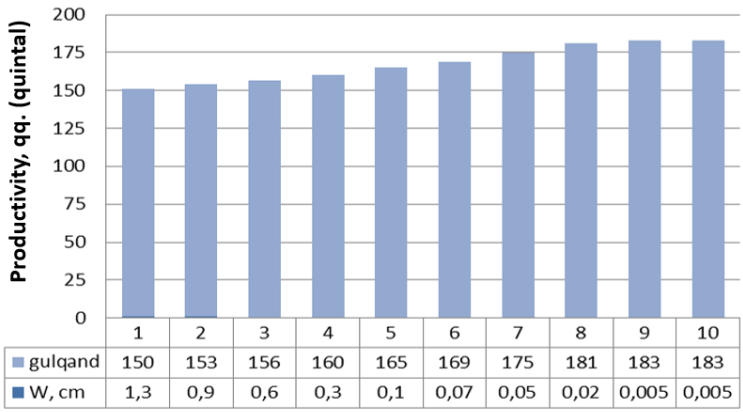


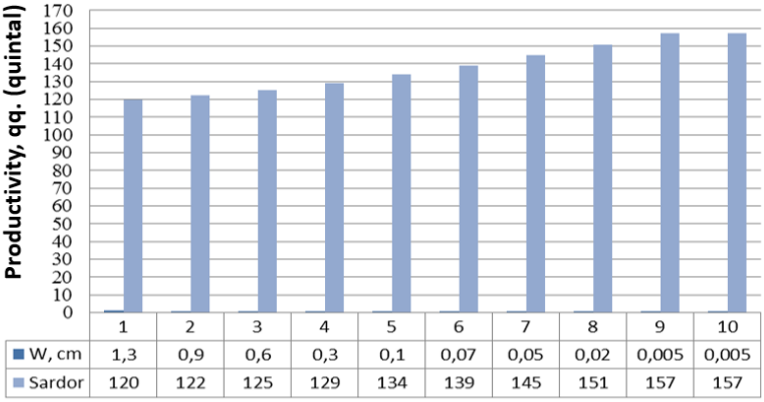
Fig. 3. In the application of the electrohydraulic effect, the disintegration of solid particles in the water composition is contingent upon the capacitance of the capacitor



	1	2	3	4	5	6	7	8	9	10
gulqand	150	153	156	160	165	169	175	181	183	183
W, cm	1,3	0,9	0,6	0,3	0,1	0,07	0,05	0,02	0,005	0,005

Fig. 4. In the application of the electrohydraulic effect, the tomato (variety Gulqand) yield is influenced by the fragmentation of solid particles in the water composition

In the experiments, it was found that the capacitor capacity of 0.8 μF in the electrohydraulic effect treatment of liquid feed is sufficient for the decomposition of fertilizers in water to a level easily absorbed by plants (0.05 cm). Increasing the capacitor capacity from 0.8 μF does not change the decomposition rate of fertilizers in water (Figure 3).
Experimental studies were conducted on the influence of the decomposition level of liquid nutrients on plant productivity. The results of the experiment show that the more the waste in the liquid solution is broken down, the easier it is for the plant to absorb nutrients. As a result, productivity increases. In mixtures treated by mechanical method, the size of the liquid is on average 1-1.3 cm. These nutrients are not absorbed into the soil and are not absorbed by plants. We can see that the average yield in tomato cultivation according to the current technology was 150 qq, and after processing with electrohydraulic effect, the yield was 183 qq, that is, the current technology of tomato cultivation has increased by 33 qq (Figure 4).



	1	2	3	4	5	6	7	8	9	10
W, cm	1,3	0,9	0,6	0,3	0,1	0,07	0,05	0,02	0,005	0,005
Sardor	120	122	125	129	134	139	145	151	157	157

Fig. 5. In the application of the electrohydraulic effect, the cucumber (variety Sardor) yield is influenced by the fragmentation of solid particles in the water composition

The average yield of cucumbers according to the used technology was 120 qq, and after processing with the electrohydraulic effect, the yield was 157 qq (Figure 5). This is 37 times more than the current cucumber cultivation technology.

5. Conclusion

According to the results of the analysis of technologies of feeding plants by fertilizing, the amount of fertilizer absorbed by plants is 30-40%. This indicator shows that the efficiency of fertilization of plants today is very low.
In order to increase the efficiency of plant nutrition, it is necessary to break down large quantities of fertilizers into the liquid solution, to make them easily absorbed by plants, and at the same time to neutralize the bacteria in the liquid solution fertilizer.
The following parameters were determined for the maximum decomposition of solids contained in the fertilizer by electrohydraulic treatment of liquid solution fertilizer and increasing the efficiency of plant nutrition. The discharge voltage is 24 kV, the number of pulses is 175, the capacitor capacity is 0.8 μF. This makes it possible to break down solids in the fertilizer to 0.002 cm, which are difficult for plants to absorb.
Modes and parameters of the electrohydraulic effect processing, which ensures the breakdown of solids of liquid fertilizers up to 0.002 cm, have been determined, and this allows to increase the productivity of cultivated plants up to 33-37 qq.

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