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Treatment Of Maize Seeds Using An Ultraviolet Irradiation Device

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Abstract. The article presents the results of studies on the technological parameters of an electrotechnological device used for pre-sowing ultraviolet treatment of maize seeds, as well as the optimal processing parameters for electrical stimulation and their relationship with crop yield indicators.
Key words: Maize seeds, ultraviolet radiation, DNA, RNA, seed receiving hopper, conveyor belt, accumulator, inverter, gearbox, germination capacity, accepted schemes of ultraviolet seed treatment, yield.

INTRODUCTION

The implementation of scientific developments aimed at fulfilling the tasks defined by the Decree of the President of the Republic of Uzbekistan No. PF-60 dated January 28, 2022, "On the Development Strategy of the New Uzbekistan for 2022–2026" [1], as well as the Resolution No. PQ-227 dated June 20, 2024, "On Additional Measures to Accelerate Reforms in the Agricultural and Food Sectors", and other relevant regulatory and legal documents, is considered one of the most important objectives [2].

At present, various electrotechnological methods are widely applied in agricultural crop production. Pre-sowing seed treatment includes two main processes: disinfection and stimulation (i.e., improvement of seed sowing quality). The primary disinfection method involves the use of aqueous solutions of toxic chemical agents (pesticides). However, while such chemicals protect seeds from soil- and seed-borne infections, they may simultaneously reduce seed sowing quality.

One of the methods for improving seed sowing quality is pre-sowing hot-air treatment carried out 10–14 days before planting. This method makes it possible to increase germination capacity, germination energy, and crop yield even without additional pre-sowing treatments [3]. Therefore, extensive scientific research is currently being conducted to improve methods and technical means for enhancing the sowing quality of cereal crop seeds. These methods aim to completely eliminate surface seed infections while improving sowing characteristics. In this process, seeds are kept in a moist state for 3–5 minutes and then treated in a high-frequency electromagnetic field with a frequency range of 10^8 to 10^{10} Hz. However, after seeds are placed in the soil, they remain unprotected against insect pests and sources of infection present in the soil and air. In the future, this method may be improved by moistening seeds with microelement solutions and applying growth stimulants. The application of this approach can increase cereal crop yields by an average of 20%.

After ultraviolet irradiation of grain seeds, the permeability of cell membranes changes, resulting in up to a 10% increase in water absorption. These effects persist throughout the entire germination period [4, p. 115]. Following irradiation, protein degradation processes in the endosperm accelerate, while protein synthesis intensifies in germinating seedlings. In addition, irradiated grains release soluble forms of nitrogen more rapidly, leading to faster carbohydrate breakdown and enzyme activation. All these processes contribute to the accelerated formation and development of germinating seedlings.

Literature Review. In the article by Kasatkina and Ziganshina entitled "Optimal Duration of Pre-Sowing Electric Field Exposure on Wheat Seeds and Its Effect on Grain Quality and Yield", various device configurations based on the stimulation of seeds by corona discharge prior to sowing were developed [5, pp. 83–87]. One variant of such devices is presented in Figure 1 below.

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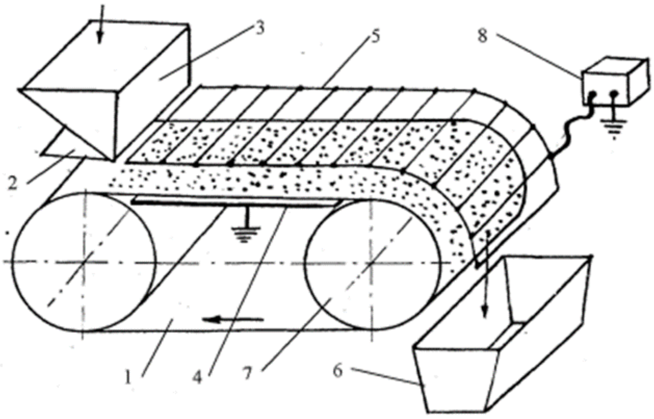

1 – loading and receiving hopper;
2 – hopper support frame;
3 – hopper;
4 – conveyor belt support platform;
5 – corona electrode;
6 – receiving hopper;
7 – drive drum;
8 – power supply.

Figure 1. Electrotechnological treatment of seeds

In their research, Kasatkina and Ziganshina emphasized that the time factor plays a key role in the pre-sowing treatment of seeds with an electric field. They provided scientific justification that selecting an optimal exposure duration makes it possible to improve both the quality and quantity of the crop yield. RNA (ribonucleic acid), in turn, copies information from DNA and regulates protein synthesis.

High-energy photons of ultraviolet radiation (UVR), particularly in the wavelength range of 254–280 nm, directly affect DNA molecules in seeds as follows: thymine dimers (T=T) are formed, whereby adjacent thymine bases bond to each other under UV exposure, resulting in dimer formation. This process disrupts normal DNA replication and transcription.

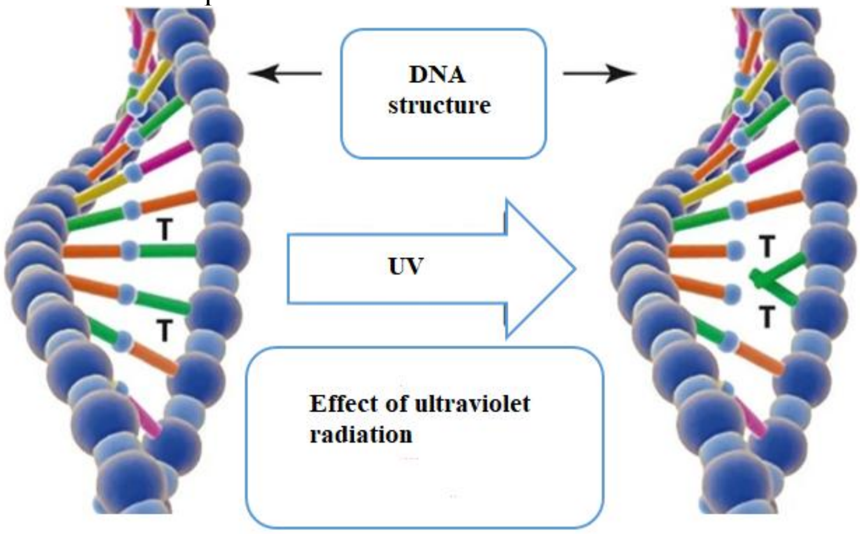

Figure 2. Effect of ultraviolet radiation on seeds

The consequences of DNA alterations in maize seeds exhibit positive effects at low doses: stress-induced adaptation occurs; the synthesis of DNA and RNA activates protective genes (PR genes, SOD, POD, CAT); enzyme activity in seeds increases (α-amylase, peroxidase, etc.); and germinal proteins are synthesized more rapidly, leading to faster and more stable seed germination.

Conversely, the consequences of DNA alterations in maize seeds at high doses are negative: excessive UV radiation causes DNA degradation, mutations, or inhibition of DNA replication; transcription is

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disrupted, which leads to impaired protein synthesis and, consequently, failure of seed germination or delayed growth.

Research Methodology: Under laboratory conditions, the optimal parameters for seed germination were determined when maize seeds were treated with ultraviolet radiation [6, pp. 1–6]. Based on these optimal parameters, an electrotechnological device for ultraviolet treatment of seeds was designed (Figure 3). Using the optimal parameters obtained under experimental conditions, the seeds treated with the electrotechnological device were sown in field plots. Under field conditions, the germination indicators of the treated seeds also showed high performance (Table 1).

During the maize growth stages (1, 2, and 3), ultraviolet radiation in the UV-B and UV-C ranges was applied three times, along with the use of electroactivated water. As a result of phenological observations, the biometric parameters of the control and experimental variants were compared, and the experimental variant demonstrated significantly higher indicators than the control. After the maize grain reached full maturity, the mass and number of kernels per ear, as well as stem biomass, were determined. The economic efficiency indicators of the control and experimental variants were compared, and the application of the proposed electrotechnology provided an additional profit of up to 3,840,000 UZS per hectare.

Figure 3. Device for ultraviolet treatment of seeds

Analysis and Results: In the conducted scientific and applied research, field germination indicators of two maize varieties (O‘zbekiston 601 ESV and O‘zbekiston 300 MV) were presented for both control and experimental variants (Table 1). An analysis of the obtained results relative to the control showed that the results of Variant 3 demonstrated optimal values compared to the other variants, which was attributed to the application of electrotechnological treatment.

Table 1

Effect of ultraviolet radiation on germination and viability of maize varieties

Maize seed varieties and experimental treatments			**Day of Reckoning**					**of germinated seeds %**	**Ungerminated seeds %**	**Germination rate %**	**Viability %**
			6	**7**	**8**	**9**	**10**				
			Number of seedlings, pcs.								
Uzbekistan	1	Control	131	158	203	203	148	84,3	15,7	18,6	82
	2	254,3+300nm	179	243	256	198	41	91,7	8,3	9,05	90,3

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601	3	254.3+300nm (seed, soil and stem irradiated, EFS)	182	240	250	202	44	91,8	8,2	8,9	90,2
Uzbekistan 300	1	Control	135	162	210	221	104	83,2	16,8	20,1	83,4
	2	254,3+300nm	182	240	254	201	25	90,2	9,8	10,8	89,4
	3	254.3+300nm (seed, soil and stem irradiated, EFS)	188	232	243	196	42	90,3	9,7	10,7	89,5

Note: Here EFS-electrolyzed water

Figure 4 below presents an analysis of the average grain yield results based on the economic indicators of the Uzbekistan 601 ESV and Uzbekistan 300 MV varieties in cultivation for 2023 2025.

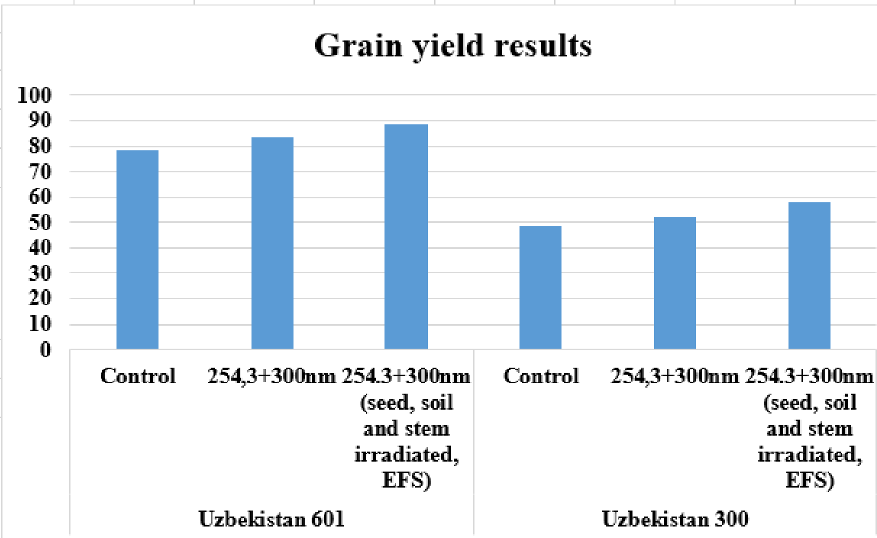

Figure 4. Grain yield results

Figure 5 below presents an analysis of the average conditional net income results based on the economic indicators of the Uzbekistan 601 ESV and Uzbekistan 300 MV varieties in cultivation for 2023-2025.

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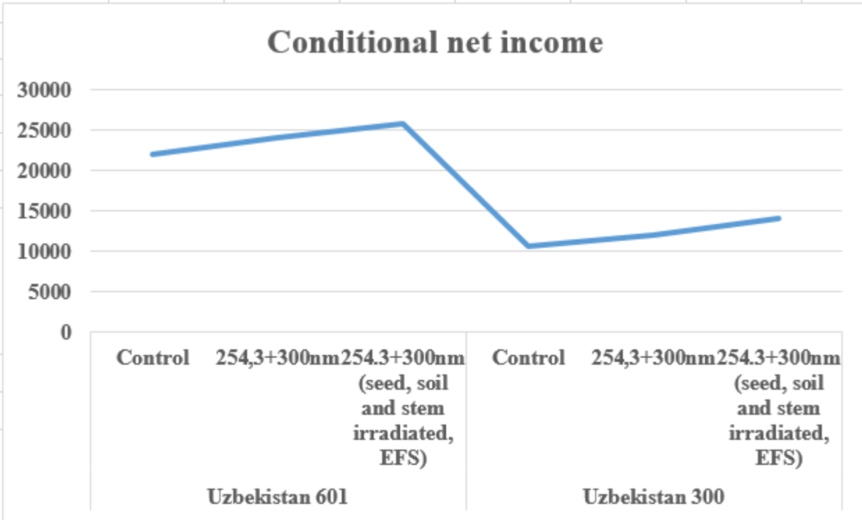

Figure 5. Conditional net income

From Figure 5, it can be seen that if we use the proposed electrotechnology to grow corn at an additional cost of 500,000 soums compared to the current method, the yield will increase by 9.4-10.1 tons of grain per hectare and 9.8-15 tons of silage per hectare compared to the control option, and the net income from 1 hectare at current prices per hectare will be up to 3,840,000 soums.

CONCLUSION

Based on the analysis of the data obtained from the experiment, the following conclusions can be drawn. The methods of complex and staged electrotechnological processing for increasing productivity in corn cultivation are considered effective. Because, when processed with this method, productivity-increasing electrotechnological effects are exerted on the seeds, soil, and plant, and as a result, the biometric indicators of corn increase. When seeds and soil are treated with ultraviolet light before sowing corn seeds, the degree of germination of seedlings depends on the rate of irradiation, processing time, and processing interval, and a functional relationship between these indicators was determined. As a result, the optimal parameters of UBN processing for increasing the germination and viability of corn seeds were determined. When comprehensive and staged seed, soil, and plant treatment is performed before planting 25 kg of corn seeds per hectare, the expected economic efficiency will be 3,840,000 soums per year, with a yield increase of 9.4-10.1 tons compared to current corn cultivation technology.

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