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Determination Of Optimal Parameters For Pre-Sowing Electrical Treatment Of Corn Seeds

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Abstract

This paper presents the results of laboratory studies on a pre-sowing electrical treatment method aimed at enhancing the germination capacity of corn seeds. The study investigates an electrotechnological approach based on the application of ultraviolet radiation (UVR), in which the effect is achieved through the electrical stimulation of seeds. An analysis was conducted to determine the optimal treatment parameters, including ultraviolet wavelength, exposure distance, and irradiation duration applied prior to sowing. The results identify favorable combinations of these parameters that contribute to improved germination performance and early seedling development.

Keywords: Corn seeds; electrical treatment; electrical stimulation; ultraviolet radiation (UVR); quartz method; germination; wavelength; exposure distance; exposure time.

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1. Introduction

Corn (Zea mays L.) is one of the most widely cultivated cereal crops in the world and is of considerable economic importance. It serves as a major food source and is extensively used in animal feed production, biofuel generation, industrial processing, and numerous other sectors. In addition, corn and its derivatives are applied across various fields, including agroelectrotechnology, the food industry, pharmaceuticals, and related industries.

Globally, extensive research is being conducted to develop resource- and energy-efficient technologies aimed at increasing crop productivity within the “seed–soil–plant” system, as well as innovative scientific and technical solutions for the equipment used to implement these technologies. In this context, there is a growing demand for energy- and resource-saving devices that improve crop performance indicators through staged electrotechnological pre-sowing seed treatments.

In particular, the adoption of agroelectrotechnological methods that enhance germination capacity, growth vigor, disease resistance, and overall productivity of corn in agricultural practice, along with the scientific justification of their optimal operating parameters, remains a pressing and relevant research objective.

2. Literature Review

Numerous studies conducted by international researchers have demonstrated the effectiveness of electrical and electromagnetic treatments in improving the physiological and growth characteristics of corn seeds. In particular, research carried out by Yao Lu, Yaoyao Li, Qian Peng, Xiangyun Sun, Qinglu Yang, Zhanghua, Fuyang Tian, Yinfa Yan, and Mochen Liu investigated the treatment of corn seeds under cold stress conditions using a high-voltage electric field with a strength of 1.6 kV/cm. The experimental results showed that seed viability and growth potential increased by 11.7%, viability and growth rate by 11.2%, and the viability and growth index by 10.5%. Moreover, the vigour index increased by 31.7%, root length by 20.3%, shoot height by 19.2%, and plant dry mass by 16.6%. In addition, an increase in soluble sugar content was observed in the seeds, cell membrane damage was reduced, and positive changes in cell wall expansion and cellular structure were reported [1].

In studies conducted by Muhammad Faraz Ali, Muhammad Sojid Aqil Ahmad, Abdel-Rhman Z. Gaafar, and Awais Shakoor, corn seeds were treated using an electromagnetic field (EMF) prior to sowing. The results indicated a significant improvement in germination kinetics, meaning that the germination process was accelerated and a greater number of seeds successfully germinated. Compared with the control group, positive effects were observed in terms of the onset and rate of germination, as well as the initiation and intensity of seedling growth [2].

Research by Navid Taghizadeh Sedighi, Majid Abedi, and Seyed Ehsan Hosseini, entitled “Effects of electric field strength and exposure time on certain physiological characteristics of corn seeds”, examined the impact of applying electric fields of varying intensities (2, 4, 9, and 14 kV/m) for different exposure durations (15, 45, 80, and 150 s). The findings revealed that the number of germinated seeds and the growth energy of seeds increased with exposure time; however, prolonged treatment under high electric field strength led to damage to the seedlings. For instance, an electric field strength of 9 kV/m with an exposure time of approximately 45 s was identified as optimal for achieving moderate and stable results. Following treatment, increases were observed in germination rate, shoot and root length, as well as fresh and dry biomass [3].

Furthermore, Lukas M. Ferroni, Moira I. Dolz, María Florencia Guerra, and Leonardo Makinistyan conducted experimental studies on the stimulation of corn seed growth using a static magnetic field. In this work, seeds were exposed to magnetic field intensities ranging from 50 to 350 mT for different durations. The most pronounced positive effect was recorded at 150 mT, where the stem length or early-stage plant height increased by an average of 10.9%. Significant growth stimulation was also observed at other intensities; however, negative effects were reported at 350 mT [4].

3. Methods

The laboratory germination capacity of corn seeds of the “Uzbekiston 601 ESV” variety was evaluated under controlled conditions in three replications. Prior to experimentation, seeds were visually inspected and uniform samples were selected to ensure consistency in size, shape, and physical condition.

The experimental studies were conducted in the laboratory of the Department of Electrical Technology at the Kokand Branch of Tashkent State Technical University named after Islam Karimov, as well as at the Fergana Regional Scientific and Experimental Station of the Research Institute of Grain and Leguminous Crops.

Pre-sowing electrical stimulation of corn seeds was carried out using ultraviolet radiation (UVR) as the primary electrotechnological treatment factor. The treatment was performed according to the “quartz method”, in which seeds are exposed to ultraviolet radiation emitted by bactericidal lamps. For each experimental variant, 30 seeds were selected and subjected to treatment [5].

The experiments were conducted under different irradiation regimes. The distance between the ultraviolet radiation source and the seed surface (HUVR) was set at 5, 10, and 15 cm, while the exposure duration (tUVR) was 3, 6, and 9 minutes. Ultraviolet irradiation was applied at wavelengths of $\lambda = 253.7$ nm and $\lambda = 300$ nm, using two bactericidal lamps with a rated power of 30 W each.

After treatment, the seeds were placed in Petri dishes on moistened filter paper and incubated under laboratory conditions at a constant temperature. Germination tests were performed in accordance with generally accepted seed testing methodologies. A seed was considered germinated when the radicle length reached the standard criterion.

The following indicators were evaluated: germination percentage, germination energy, root length, and shoot length. The obtained experimental data were processed using standard statistical methods. Mean values were calculated for each treatment variant, and comparative analysis was carried out to assess the influence of ultraviolet radiation wavelength, exposure distance, and treatment duration on seed germination and early growth parameters.

4. Results

After irradiation, the treated corn seeds were placed in a climate chamber. Seed germination commenced on the second day following treatment. By the fourth day, the germination process had stabilized, and by the tenth day, all viable seeds had been clearly identified.

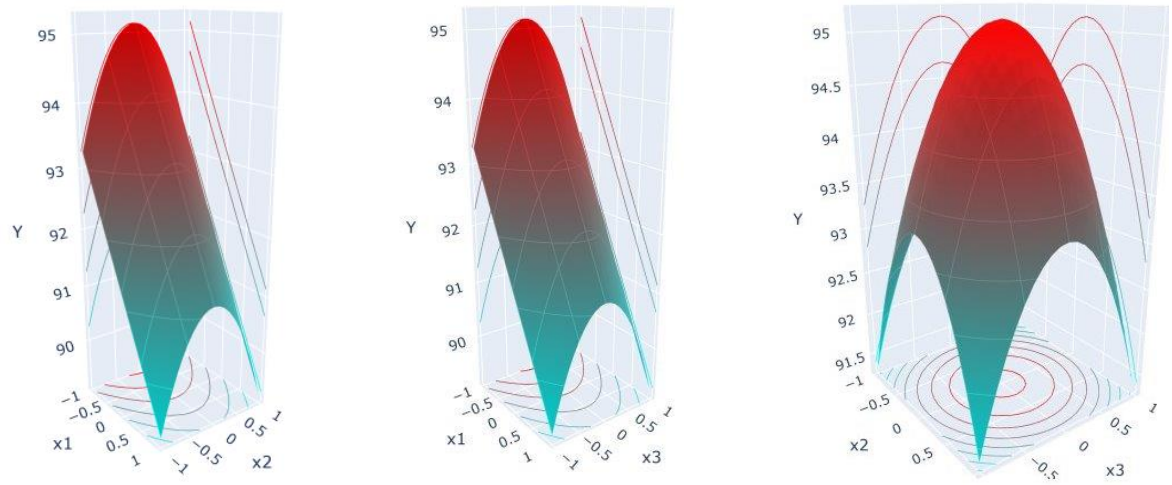
Table 1 presents the germination results of corn seeds of the "Uzbekiston 601 ESV" variety following ultraviolet irradiation at wavelengths of 253.7 nm and 300 nm.

The experimental results demonstrated that when ultraviolet radiation with wavelengths of 253.7 nm and 300 nm was applied, at a distance of 10 cm between the radiation source and the seeds, exposure duration of 6 minutes, and using bactericidal lamps with a total power of 60 W, the germination capacity of corn seeds reached 96.6% (Table 2). This value represents an increase of 7.9% compared with the control variant (untreated seeds).

These findings indicate that the combined effect of ultraviolet wavelength, exposure distance, and irradiation duration plays a significant role in enhancing seed germination. The identified treatment parameters can therefore be considered optimal under the given laboratory conditions for improving the germination performance of corn seeds prior to sowing.

Table 1. Main experimental factors, their levels, and ranges of variation.

№	Factors and units of measurement Power of UV irradiation lamps, W	Symbol	Coded symbol		Variation interval	Limit of change of factors		
			True	Coded		-1	0	+1
1	Distance of UV irradiation, cm	P	X_1	x_1	30	30	60	90
2	Duration of UV irradiation, min	N_{ubn}	X_2	x_2	5	5	10	15
3	Factors and units of measurement	t_{ubn}	X_3	x_3	3	3	6	9



a) b) c)

Figure 1. Germination capacity of corn seeds of the *"Uzbekiston 601 ESV"* variety:
(a) variation as a function of factors X_1 and X_2 at $X_3 = 0$;
(b) variation as a function of factors X_1 and X_3 at $X_2 = 0$;
(c) variation as a function of factors X_2 and X_3 at $X_1 = -1$.

Table 2. Results of the study on pre-sowing electrical treatment of corn seeds of the "Uzbekiston 601 ESV" variety

P, Vt; *λ*, nm	H_{ubn}, sm	t_{ubn}, min	Fertility, %
P=30, λ=253,7 P=30, λ=300	5	3	91,1
		6	92,2
		9	92,2
	10	3	91,1
		6	96,6
		9	92,2
	15	3	91,1
		6	92,2
		9	91,1
		9	91,1
Control	-	-	88,7

Figure 2 below shows samples of seedlings of the "Uzbekistan 601 ESV" variety obtained by simultaneously using lamps with wavelengths of 253.7 nm and 300 nm.

Figure 2. Comparison of germination between irradiated and control seeds of the “Uzbekiston 601 ESV” corn variety.

5. Discussion

The results of the conducted scientific and applied research indicate that the germination capacity of corn seeds is directly influenced by multiple factors, including the biological characteristics of the seeds, environmental conditions, and the methods applied during pre-sowing treatment. The experimental findings demonstrate that when optimal parameters of ultraviolet radiation were applied, seeds exhibited faster and more uniform germination.

Compared with the control treatment, a significant improvement in germination energy and overall germination percentage was observed, which contributes to the stable and uniform development of plants during the initial stages of vegetation. In addition, positive changes were recorded in the biometric characteristics of seedlings, particularly in the length of the root system and shoot, indicating enhanced early growth performance.

These results are consistent with theoretical studies suggesting that ultraviolet irradiation and electrotechnological treatments activate physiological and biochemical processes during seed germination. However, the findings also confirm that if optimal irradiation parameters are not properly defined, excessive exposure may have a negative impact on seed tissues, leading to reduced viability or damage.

Therefore, the development of scientifically justified and standardised treatment parameters is of critical importance for the practical implementation of pre-sowing ultraviolet and electrotechnological treatments in agricultural production systems.

7. Conclusions

Based on the results of this study, it can be concluded that pre-sowing electrical treatment of corn seeds, particularly through ultraviolet radiation (UVR), makes it possible to significantly enhance seed germination capacity. Laboratory investigations involving different treatment regimes—lamp power (30, 60, and 90 W), wavelengths (253.7 nm and 300 nm), exposure distances (5, 10, and 15 cm), and irradiation durations (3, 6, and 9 minutes)—allowed the identification of optimal operating conditions.

The most favourable results were obtained when seeds were irradiated at a distance of 10 cm for 6 minutes using lamps with a power of 30 W at wavelengths of $\lambda = 253.7$ nm and $\lambda = 300$ nm. Under these conditions, a pronounced improvement in germination performance was observed. Seeds treated with ultraviolet radiation exhibited higher germination energy and more stable early growth compared with untreated samples.

As a result, the application of ultraviolet-based pre-sowing electrical treatment has the potential to contribute to an increase in corn productivity, highlighting its practical relevance for agricultural production when applied under scientifically substantiated parameters.

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