The effectiveness of growth processes' electrostimulation in corn hybrid seeds rodnik 180 sv

S.P. Appaev [1,*], *A.R.* Kotseva [1], *O.H.* Mataeva [1], *A.R.* Yandieva [1], and *E.B.* Khatefov [2]

[1] Institute of Agriculture – branch of the Kabardino-Balkarian Scientific Center of the Russian Academy of Sciences, 360004 Kabardino-Balkarian Republic, Nalchik, Kirova str., 224, Russia
[2] Federal Research Center All-Russian Institute of Plant Genetic Resources named after N.I. Vavilov, 190000 Russia, St. Petersburg, B. Morskaya str., 42, 44, Russia

Abstract. The aftereffect's study of pre-sowing treatment with electric current of 500V, 1000V and 8000V on the sowing qualities and growth processes of corn hybrid seeds Rodnik 180 SV was carried out in laboratory conditions. As a result of the conducted studies, the positive effect of electrical stimulation on the germination and germination energy of corn seeds was revealed. Studies have shown the effectiveness of seeds' pre-sowing electrical stimulation according to the following traits: growth of roots and seedlings, seed swelling intensity, germination energy and germination. Laboratory germination of seeds increased by 10% compared to the standard, germination energy – by 13-15%. The swelling intensity of treated seeds was 15-17% higher. The weight of raw sprouts in the control option was 32.3g, dry – 10.2 g. The weight of raw sprouts in seeds treated with 8000V was 48.9g, when treated with 500V – 54.0g. The length of roots and seedlings when treated with 8000V ranged from 23.9 mm, at 500V - up to 44.2 mm.

1 Introduction

To ensure the country's food security, the issue of increasing the yield and gross harvest of grain crops is currently acute [1, 2]. The "Food Security Doctrine of the Russian Federation" adopted by the Decree of the President of the Russian Federation dated 21.01.2020, provides for a reduction in the share of seeds of foreign selection varieties and hybrids and an increase in the level of sowing seeds of the main agricultural crops of domestic selection to 75% [3]. The solution of this problem is possible only if high-quality seed material is used for sowing. It should be noted that with this, the sowing qualities of seeds take on one of the leading roles in the seed industry.

To improve the sowing qualities of seed material, scientists conduct a large number of studies on the effects of various physical factors on germination, germination energy, and seed growth processes. To do this, various methods of pre-sowing seed treatment are used:

* Corresponding author: kbniish2007@yandex.ru

exposure to industrial and high frequency currents, treatment with electric and magnetic fields, irradiation with ultraviolet and infrared rays, treatment with ozone-air mixture, etc.

A positive effect of pre-sowing treatment with ultraviolet irradiation on the sowing qualities of seeds was noted [4-9]. Koshkina O.A. proposed a device for pre-sowing seed treatment with thermal and electromagnetic fields [10]. At the same time, the speed of seed germination and root regrowth increases. Pre-sowing treatment of corn seeds with low-frequency electromagnetic radiation increases germination energy and germination, promotes the formation of strong seedlings and increases the dry weight in seedlings [11, 12]. Studies of the ozone-air mixture effect on corn seeds have shown a stimulating effect on the sowing qualities of seeds [13].

However, noting the generally positive effect of seed stimulation by electromagnetic fields of microwave and EHF, it has been proven that its stimulating or oppressing effect depends on the radiation dose [14].

The analysis of the studies conducted to improve the sowing qualities of seeds by various physical factors shows that there is no unambiguous opinion on this matter. In this regard, the authors conducted studies on the stimulation effect of germination, germination energy, and growth processes of corn seeds by an electric field.

2 Materials and methods

The research was carried out in 2021 in the laboratory of chemical analysis of grain crops of the Institute of Agriculture of the Kabardino-Balkarian Scientific Center of the Russian Academy of Sciences. The treatment of corn seeds with electric current was carried out in the laboratory of atmospheric electricity of the High Mountain Geophysical Institute (Rosgydromet). The study material was seeds of the corn hybrid Rodnik 180SV with an initial germination rate of 92% and germination energy of 76%. 3 options were selected to determine the threshold values of the electrical stimulation effect: 500V (Option 1), 1000V (Option 2), and 8000V (Option 3). The exposure time was 1 hour. Seeds with no treatment served as a control. Germination and determination of seed sowing qualities were carried out in accordance with GOST 12038-84 "Seeds of agricultural crops. Methods for germination determining". Germination was carried out in a thermostat at a temperature of + 25^0C in rolls of filter paper, in the dark with constant wetting. Germination energy was determined on day 4, germination – on day 7. The growth dynamics of the root system and seedlings were determined on days 3, 5, 7, and 9. The seeds were examined on the sixth day. Seeds that had rotted and produced abnormal seedlings were removed. The top layer of filter paper was replaced with a new one. The assessment of seedlings' growth strength was carried out visually by the length of the main root and the seedling length, the seedling weight. The weight of raw and dry seedlings was determined by weighing on electric scales before (raw) and after (dry) drying in a drying cabinet for 24 hours at a temperature of +104ºC. The assessment of seedlings' strength and energy was carried out visually. The intensity of seed swelling was determined by soaking the seeds in distilled water with neutral pH level in a thermostat at a temperature of +20 °C [15, 16]. Accounting of swelling in dynamics was carried out after 1h, 3h, 7h, and 24h after the start of soaking. The research results were processed using the "Statistica10" software package.

3 Results and discussion

The seed germination energy provides a sufficiently informative characteristic of the sowing qualities of seed batches: seeds with high germination energy give uniform and strong shoots, which allows to expect an increase in productivity. Changing the values of this trait is one of

the criteria for evaluating the effect after seed treatment with electric current.

The authors evaluated laboratory germination, germination energy, weight of raw sprouts and weight of dry corn seed sprouts under pre-sowing stimulation with a constant electric field of various voltages. The results of the studies are shown in Table 1.

Table 1. Indicators of corn seeds' sowing qualities after treatment with an electric field of various voltages

Option	Energy of germination, %	Germination capacity, %	Weight of raw sprouts, g	Dry weight of sprouts, g
1	2	3	4	5
Control, no treatment	75	92	32.3	10.2
Option 1 500 V	88	100	45.5	15.5
Option 2, 1000 V	89	100	47.2	15.8
Option 3, 8000 V	90	100	48.9	16.1
LSD_{05}	6.3	7.8	4.3	2.1

Results' analysis shows that seeds' stimulation with a high-voltage electric field significantly increases the germination energy and seed germination. Thus, untreated seeds showed germination energy at the level of 75%, whereas treated seeds had a minimum value of this indicator at the level of 88%, the maximum – 92%. Seed germination of the control sample was 90%. The treated seeds showed 100% germination regardless of voltage amount.

The effect of seeds' electric stimulation was manifested in a change in the values of laboratory seed germination and had an impact on the sprouts' weight. Thus, the weight of raw sprouts of the control option amounted to 32.3 g, dry – 10.2 g. The maximum raw sprouts' weight of treated seeds in the 8000V treatment option was 48.9 g, the minimum was 54.0 g in the 500V treatment option. A similar trend was revealed when measuring the weight of dry corn seedlings.

Pre-sowing seed treatment affects many physiological characteristics of the plant organism, including changes in the water permeability of the cell membrane. One of the indirect methods of this characteristic is the measurement of seed swelling intensity [17].

Analysis of the data obtained shows that electrical stimulation has a significant effect on the rate and magnitude of seed swelling, which indirectly indicates an increase in the water permeability of cell membranes (Table 2). Thus, the value of swelling in the control option (no treatment) after 24 hours was 126.1%. Seeds treated with 500V, 1000V and 8000V voltage doses showed swelling values during soaking up to 143.3, 142.1, and 141.1%, which is significantly higher than that of the control option by 17.2, 16.0, and 15.0%, respectively. The variation in the weight of swollen seeds ranged from 0.86 to 1.36 grams compared to the control sample.

Table 2. Intensity of corn hybrids' seed swelling

Option	Seed weight, g					Seed weight after 24 hours, %
	Before soaking	after 1h	after 3h	after 7h	after 24h	
Control, no treatment	6.3	6.42	6.99	7.1	7.94	126.1
Option 1, 500 V	6.5	7.0	7.2	8.5	9.3	143.3

Option 2, 1000 V	6.2	6.7	7.3	8.3	8.8	142.1
Option 3, 8000 V	6.6	7.1	7.6	8.6	9.3	141.1
LSD_{05}					**0.63**	

All seeds were placed in a thermostat for germination to determine the effect of electrical stimulation on the germination intensity of seedlings and roots. The seeds were examined on the sixth day; rotten seeds and those giving abnormal seedlings were removed. The top layer of filter paper was replaced with a new one.

Analysis of the research results shows that electrical stimulation had a significant impact on the germination rate and growth of both the root system and corn seedlings (Table 3, Table 4).

The analysis showed that only 30% of the seeds germinated in the control group on the 3rd accounting day, while the treated seeds germinated completely, and the average root length ranged from 23.9 mm at an electric current voltage of 500V to 44.2 mm at the same voltage. The range of variation was 0 – 5.0mm for seeds without treatment and from 10.0 mm to 56.0 mm for seeds subjected to electrical stimulation. A similar pattern was observed in terms of the seedling length indicator: the average length in the control was 1.4 mm, and it reached 19.6 mm in seeds with electrical stimulation. At the same time, the range of variation was in the range from 0 to 5.0 mm for control and from 5.0 to 41.0 mm for seeds subjected to electrical stimulation. This trend continues on the 5th, 7th, and 9th days. The growth of the root system and the aboveground part occurs much better in seeds treated with electric current of various voltages.

Analysis of the aftereffect results of electric current in the studied doses on corn seeds shows that an increase in voltage from 500V to 8000V has an ambiguous effect on growth processes. It was found that at a voltage of 500V and a voltage of 1000V, the growth processes accelerated more, and the accumulation of vegetative parts' mass occurred faster than when treating with a voltage of 8000V.

The results of the studies showed that the studied electric current treatment options had a stimulating effect on the laboratory germination of seeds and the growth of the primary (germinal) root and seedling.

Table 3. The effect of electrical stimulation on root regrowth

Hybrid/Dose	Indicator	Length, mm			
		3 days	5 days	7 days	9 days
Control, no treatment	Average	23.92	47.6	87.28	120.36
	Range of variation	10-40	30-70	55-110	75-130
Option 1, 500 V	Average	34.96	70.2	108.96	149.6
	± to st.	12.04	22.6	21.68	29.24
	Range of variation	14-56	62-110	63-133	110-240
Option 2, 1000 V	Average	36.96	73.2	121.88	168.8
	± to st.	13.04	25.6	34.6	48.44
	Range of variation	10-53	47-103	58-107	80-220
Option 3, 8000 V	Average	33.16	62.56	95.76	133.8
	± to st.	9.34	14.96	8.48	13.56
	Range of variation	20-43	32.75	60-145	100-170

Table 4. The effect of electrical stimulation on seedlings' regrowth

Hybrid/Dose	Indicator	Length, mm			
		3 days	5 days	7 days	9 days
Control, no treatment	Average	1.4	4.76	13.64	26.52
	Range of variation	0-5	2-15	5-18	20-35
Option 1, 500 V	Average	11.88	31.56	59.96	89.68
	± to st.	10.4	26.8	46.32	63.16
	Range of variation	5-10	15-53	38-90	60-140
Option 2, 1000 V	Average	19.68	44.4	77.64	108.0
	± to st.	18.28	39.64	64.0	81.48
	Range of variation	5-30	15-75	38-118	30-170
Option 3, 8000 V	Average	15.2	27.12	50.44	74.4
	± to st.	13.8	45.68	36.8	47.88
	Range of variation	5-41	15-50	34-72	40-100

4 Conclusions

The research results have shown that the effect of an electric current with a voltage of 500V, 1000V and 8000V on seeds has a significant stimulating effect on several traits that determine the sowing qualities of corn seeds. Threshold values of the stimulating effect of the electric current voltage for the exposure modes studied in the experiment were not found. It is possible that these thresholds are above 8000 V when dry seeds are exposed for 1 hour. Analysis of changes in the values of some traits after corn seeds' electric stimulation showed its effectiveness in terms of such traits as water absorption capacity, increase in growth rate, germination energy, and germination. Pre-sowing treatment of dry seeds with an electric field in the studied processing modes significantly improves the sowing qualities of seeds by increasing germination, growth rate, and seed germination energy, which is of key importance for the initial stage of corn organogenesis and determines the future yield of its grain.

Given the positive effect of electric stimulation on sowing qualities, it is necessary to continue research in this direction to find out the duration of electric stimulation aftereffect and determine the dynamics of its decline.

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