Study of variants of pre-sowing preparation of melon seeds in high voltage electric fields

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Abstract. The research was conducted to study the influence of electrophysical effects on melon seeds and their development, as well as to identify the most effective variant of pre-sowing stimulation and treatment mode. As an agro-technological task, we evaluated the possibility of realising the development potential inherent in the seeds of melon plants, which could be realised using electrical stimulation, with minimal negative impact on the ecology of the environment. To study the effect of high voltage electric fields (DC, AC, pulse) on gourd seeds before sowing, a specially assembled setup was used. Treatment of pumpkin seeds in the electric field of constant high voltage showed that on the 3rd day there were 100% of germinated seeds, in the electric field of variable high voltage – 50%, in the electric field of pulsed high voltage – 30%, pumpkin seedling in the treatment in the electric field of constant high voltage was longer in 9.0 and 3.6 times than in the control and other treatments; treatment of watermelon seeds in the electric field of constant high voltage showed that on the 3rd day there were 70 % of germinated seeds, in the electric field of variable high voltage – 20 %, in the electric field of pulse high voltage – 40 %; watermelon germ at treatment of seeds in the electric field of constant high voltage was longer in 1,5...2,0 times than in the control and other treatments.2.0 times longer than in other treatments. High effect on the destruction of pathogenic microorganisms was observed when seeds were treated in the electric field of pulsed high voltage – the number of pathogenic microorganisms on the seed coat of watermelon and pumpkin was 4.25 and 4.1 times lower compared to the control; when treated in the electric field of constant high voltage, their number was also 3.0 times less, but the treatment of seeds in the electric field of alternating high voltage recorded an increase in pathogenic microflora in 2.0 and 1.2 times. The highest yields of watermelon and pumpkin were obtained with pre-sowing seed treatment in the electric field of constant high voltage – by 25.5 and 37.8 %; in the field of alternating voltage – by 15.7 and 27.0 %; in the field of pulse voltage – by 9.8 and 5.4 %.

Key words: melon crops, electric field treatment, seed germination, number of pathogenic microorganisms, yield.

1 Introduction

Among crop products, melons have always been regarded as a treasure trove of mineral and organic nutrients capable of maintaining and restoring the normal functioning of the body. The fruits of these crops are characterised by the presence of such functionally important components for human health as glucose, fructose, sucrose, organic acids – malic, citric, formic, essential oils, enzymes, vitamins, pectins, etc. [1, 2].

Harvesting quality crop production in the quantity required by the consumer directly depends on the quality of seeds and their development in the initial period, when the basis for the future crop is laid. These issues define complex tasks for seed production, which can be solved not only by obtaining new seeds, but also by effectively using seeds of existing varieties that have been pre-treated, improved seed quality and prepared for application to the soil [3]. Improvement of seed sowing qualities is equal in its importance to such activities as soil preparation and creation of nutritional regime for plants, therefore, improvement of seed sowing qualities is a reserve of yield increase [4].

Nowadays, crop production uses a variety of methods and ways of preliminary preparation of seeds, including melon crops, for sowing, thus realising the main positive effect of such pre-sowing treatment – to awaken the seed embryo to active life even before its introduction into the natural habitat – in the soil.

One of the effective electrotechnological operations [5] is pre-sowing stimulation of seeds of various cultivated crops [6]. Its efficiency, positively manifested

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in the development of cultivated crops, has been proved by numerous studies, analysis of the results obtained, and implemented technologies for seed treatment in the field of high DC, AC and pulse voltage [7–10]; in the magnetic field [11]; in the field of corona discharge [12]; low-temperature plasma [13] and others. The positive influence of the above mentioned electrophysical methods and effects is confirmed by uniform and friendly sprouting of sown seeds; obtaining higher yields of quality products; reducing the spread and development of various negative microflora and pathogens in crops and harvested crops.

The **aim of the research** was to study the influence of pre-sowing stimulation of melon seeds in electric fields of high DC, AC and pulse voltage with different parameters of electrophysical influence on their sowing characteristics, growth and development of watermelon and pumpkin plants, development and distribution of harmful pathogens on seed coats, as well as to identify the most effective variant of pre-sowing electrical stimulation and treatment mode.

2 Materials and methods

The research was conducted on agricultural lands of the left-bank Volga region of Volgograd region, during which the influence of pre-sowing seed stimulation in high voltage electric fields on germination of seeds of melon crops – watermelon and pumpkin; development and distribution of harmful pathogens on the seed coat; plant development; formation and structure of the harvested crop was studied.

Treatment in electric field of different high voltage was studied on seeds of watermelon variety "Sinchyovsky" and pumpkin variety "Zorka". The soil after perennial grasses served as a precursor, on which experimental plots with a total area of 70 m^2 were placed.

Sowing was carried out in the following dates: for watermelon – in the last five days of April and the first decade of May; for pumpkin – the third decade of April. The recommended depth of watermelon seeds sowing is 6...8 cm and pumpkin seeds sowing depth is 8...10 cm. Seeding rates of watermelon seeds at 100% germination depending on seed size – 1.5...3.5 kg/ha, and pumpkin – 2.0...4.0 kg/ha. Sowing patterns: watermelon – 2.5×2.0; 2.1×1.4; pumpkin – 2.5×1.8; 2.1×2.0 m.

Plant care in crops was organised in the form of three inter-row cultivations: "1" – at the sprouting of the beacon crop, "2" – in the "shatrick" phase and "3" – before closing the branches. Simultaneously with cultivation, weeding was carried out in the rows with weeding of sprouts, their straightening and covering. Harvesting of melon crops was carried out in a continuous one-time method after mass ripening.

Studies on the study of pre-sowing stimulation were conducted in accordance with a pre-specified algorithm of experiments, which took into account that the following variants of melon seeds treatment were studied: 1) control (without seed treatment in the electric field); 2) exposure of seeds to the electric field of alternating high voltage, intensity E = 5 kV/cm; 3) exposure of seeds to the electric field of constant high voltage, intensity E = 5 kV/cm; 4) exposure of seeds to the electric field of pulses of high voltage; 5) exposure of seeds to the electric field of constant high voltage, intensity E = 5 kV/cm; 6) exposure of seeds to the electric field of pulses of high voltage. In all studied variants the treatment was carried out during 60 seconds of continuous exposure [13–15].

For seed treatment in electric fields, a laboratory experimental unit was justified and assembled, the use of which made it possible to effectively carry out the electric influence, controlling and managing its parameters and modes. The electro-technological experimental installation for melon seeds treatment was assembled on the basis of industrially produced source of regulated high AC and DC voltage SKAT-70. Seeds treated in the electric field were placed in a specially made working cell, the body of which was made of dielectric material and electrodes were made of food-grade stainless steel. The lower electrode was fixed stationary, and the upper electrode was able to change its position in height above the lower base electrode. The treatment voltage supplied to the electrodes was regulated directly on the panel of the SKAT-70 apparatus, as well as the treatment time, which was set according to the timer, the latter's settings are also located on the control panel [16, 17].

Seed germination and the number of pathogenic microorganisms on the seed coat were studied in laboratory conditions. To assess the germination and growth characteristics of seedlings, the methods specified in GOST 12038-84 were used, and the results were recorded after 3 and 30 days after treatment.

The number of pathogens on the seed coat was studied using the standard classical microbiological test in Petri dishes [18].

Harvesting and accounting of yield was carried out by weighing and counting fruits, and qualitative indices of obtained products were determined on the basis of biochemical analysis of fruits.

3 Results and discussion

Fusarium, Botrytis, Penicillium, Alterraria, Mucor, Rhisopus fungi were mainly observed in the composition of pathogenic microflora. Fungal colonies were detected on the third-fourth days of observation, intensively growing from 15 to 60%, at 3...5 points. *Mucor, Penicillium* fungi showed a pronounced intensive growth [19].

The results of the experiments revealed a positive effect of exposure of seeds to high voltage electric field – a decrease in the number of pathogenic microorganisms on the seed coat was observed. High effect on pathogenic microorganisms destruction was revealed when seeds were treated in the electric field of pulsed high voltage – the number of pathogenic microorganisms on the seed coat was 4.25 and 4.1 times lower compared to the control for watermelon and pumpkin, respectively (Table 1). It should also be noted the effectiveness of seed treatment in the electric field of constant high voltage, and the controlled index for both watermelon and pumpkin was 3.0 times lower compared to the control. But when seeds were exposed to the electric field of alternating high voltage, stimulation of pathogenic microflora development was observed, which was 2.0 times more in pumpkin seeds, and 1.2 times in watermelon seeds compared to the control [20–22].

Table 1. Assessment of pathogenic microorganisms on seed coats of melon crops, pcs., 3 days after their electrical treatment

Agro-application option	Field of view of the microscope			
	1	2	3	general
Watermelon				
Control (without treatment)	36	38	45	119
Electric field of alternating high voltage $E = 5$ kV/cm	43	50	48	141
Electric field of constant high voltage $E = 5$ kV/cm	21	12	8	41
High voltage pulsed electric field $E = 5$ kV/cm	12	10	6	28
Pumpkin				
Control (without treatment)	42	28	36	106
Electric field of alternating high voltage $E = 5$ kV/cm	73	53	88	214
Electric field of constant high voltage $E = 5$ kV/cm	16	10	10	36
High voltage pulsed electric field $E = 5$ kV/cm	11	8	7	26

Table 2. Effect of electrotreatment of melon seeds after 3 days on their germination and seedling length

Agro-application option	Watermelon		Pumpkin	
	germinated seeds, %	average seedling length, cm	germinated seeds, %	average seedling length, cm
Control (without treatment)	0.0	0.0	1.0	0.2
Electric field of alternating high voltage $E = 5$ kV/cm	20.0	0.4	50.0	0.5
Electric field of constant high voltage $E = 5$ kV/cm	70.0	0.6	100.0	1.8
High voltage pulsed electric field $E = 5$ kV/cm	40.0	0.3	30.0	0.5

Treatment of pumpkin seeds in the electric field of constant high voltage showed that on the 3rd day there were 100 % of germinated seeds. At the same time, the result of fixation allowed to state that the seedling from the seeds treated in this way was 9.0 and 3.6 times longer than the seedlings in the control and other treatment variants. Treatment of pumpkin seeds in the electric field of pulsed high voltage increased their germination 30 times, but at the same time it was 20...70 % worse than in other studied treatment variants. Similar results characterised the treatment of watermelon seeds. On the 3rd day in the variant with the use of electric field of constant high voltage 70 % of seeds germinated, on the control – 0 %, and the length of seedling was 1.5...2.0 times more compared to other studied variants of treatments in electric fields (Table 2).

After 30 days, in order to determine the aftereffect of the method of pre-sowing electrotreatment of seeds, a repeated test was carried out, which allowed to see a high development of pathogenic microflora on the surface of seeds in the control variant. The composition of microflora remained the same. In the variants with treatment in electric fields of alternating and constant high voltage, a high deterrent effect was manifested – pathogenic microorganisms were 2.2...2.3 times lower in comparison with the control. Analysis of seed treatment in the electric field of pulsed high voltage showed that pathogenic microorganisms were counted in the lowest number (Table 3) [23].

Table 3. Assessment of pathogenic microorganisms on seed coats of melon crops, pcs., 30 days after their electrical treatment

Agro-application option	Field of view of the microscope			
	1	2	3	general
Watermelon				
Control (without treatment)	425	358	216	999
Electric field of alternating high voltage $E = 5$ kV/cm	158	124	172	454
Electric field of constant high voltage $E = 5$ kV/cm	140	196	103	442
High voltage pulsed electric field $E = 5$ kV/cm	30	21	15	66
Pumpkin				
Control (without treatment)	250	223	186	659
Electric field of alternating high voltage $E = 5$ kV/cm	86	93	103	282
Electric field of constant high voltage $E = 5$ kV/cm	80	110	106	296
High voltage pulsed electric field $E = 5$ kV/cm	20	18	12	50

Repeated analysis of germination showed a significant decrease compared to observations after 3 days: the percentage of germinated seeds in pumpkin seeds was 1...3 %, in watermelon – 1 % (Table 4).Observations showed that in the variant with treatment in the electric field of constant high voltage, mass germination was obtained in 7 days, which was 8 days earlier compared to the control and 5...7 days earlier compared to other variants of electric treatment.

Table 4. Effect of electro-treatment of melon seeds after 30 days on their germination and seedling length

Agro-application option	Watermelon		Pumpkin	
	germinated seeds, %	average seedling length, cm	germinated seeds, %	average seedling length, cm
Control (without treatment)	0.0	0.0	0.0	0.0
Electric field of alternating high voltage E = 5 kV/cm	1.0	0.2	1.0	1.2
Electric field of constant high voltage E = 5 kV/cm	1.0	0.2	3.0	1.2
High voltage pulsed electric field E = 5 kV/cm	1.0	0.2	1.0	1.0

Practically the same time of fruit ripening was observed in all variants of electric treatment. The length of vegetation period for plants from treated seeds of watermelon and pumpkin in electric fields of alternating and constant high voltage decreased by 2...5 and 5 days, respectively, compared with the control and with treatment in the electric field of pulsed high voltage (Table 5) [24].

Table 5. Effect of pre-sowing electric treatment of melon seeds on the length of vegetation period, days

Agro-application option	Phases of plant growth and development			
	sowing – sprouting	sprouting – fruiting	fruiting – ripening	growing season length
Watermelon				
Control (without treatment)	15	44	40	84
Electric field of alternating high voltage E = 5 kV/cm	12	42	40	82
Electric field of constant high voltage E = 5 kV/cm	7	40	39	79
High voltage pulsed electric field E = 5 kV/cm	14	44	40	84
Pumpkin				
Control (without treatment)	12	65	50	115
Electric field of alternating high voltage E = 5 kV/cm	10	62	48	110
Electric field of constant high voltage E = 5 kV/cm	7	62	48	110
High voltage pulsed electric field E = 5 kV/cm	11	65	50	115

Yield of melon crops is the main indicator of the efficiency of elements of agro-technology of cultivation.

The results of the analysis of the harvested yield of melon crops show that the highest yield of fruits, both watermelon and pumpkin was obtained in the variant with pre-sowing seed treatment in the electric field of constant high voltage – respectively by 25.5 and 37.8 % higher than in the control. Seed treatment of watermelon and pumpkin in the electric field of alternating high voltage allowed to obtain yield exceeding the control by 15.7 and 27.0 %, and in the electric field of pulsed high voltage – by 9.8 and 5.4 %, respectively (Table 6).

Table 6. Effect of pre-sowing electric seed treatment on yield and quality of watermelon and pumpkin fruits

Agro-application option	Yield, tonnes/ha	Dry matter,%	Total sugar, %	Vitamin C, %	Acidity, %	Nitrates, mg/kg
Watermelon						
Control (without treatment)	5.1	10.0	9.15	6.00	0.107	30.4
Electric field of alternating high voltage E = 5 kV/cm	5.9	11.8	10.60	6.30	0.107	25.6
Electric field of constant high voltage E = 5 kV/cm	6.4	12.0	10.90	6.60	0.107	24.8
High voltage pulsed electric field E = 5 kV/cm	5.6	10.4	9.50	6.60	0.107	29.0
Pumpkin						
Control (without treatment)	3.7	5.8	4.50	4.25	0.097	36.6
Electric field of alternating high voltage E = 5 kV/cm	4.7	6.0	5.00	4.84	0.086	38.3
Electric field of constant high voltage E = 5 kV/cm	5.1	6.4	5.45	4.84	0.107	43.0
High voltage pulsed electric field E = 5 kV/cm	3.9	6.0	4.56	4.84	0.107	46.1
NCR05=0.46 t/ha, P %=2.46 (watermelon), NCR05=0.50 t/ha, P %=3.51 (pumpkin)						

Analysing the data of Table 6 on studying the effect of pre-sowing electric treatment of seeds on the yield and quality of fruits of watermelon and pumpkin, we can highlight the following:

1) dry matter content in harvested watermelon fruits was higher by 18.0...20.0...4.0 %, in pumpkin fruits – by 10.3...3.5...3.5 %, in variants with pre-sowing seed treatment, respectively, in electric fields of constant, alternating and pulsed high voltages, compared to the control;

2) the content of total sugar in harvested watermelon fruits was higher by 19.1...15.8...3.8 %, in pumpkin fruits – by 21.1...11.1...1.3 %, in variants with pre-sowing seed treatment, respectively, in electric fields of constant, alternating and pulsed high voltages, compared to the control;

3) the content of vitamin "C" in harvested watermelon fruits was higher by 10.0...5.0...10.0 % in variants with pre-sowing seed treatment, respectively, in electric fields of constant, alternating and pulsed high voltages, compared to the control;

4) the content of vitamin "C" in harvested pumpkin fruits was higher by 12.2 % in all variants with pre-sowing seed treatment in electric fields compared to the control;

5) nitrate content in harvested watermelon fruits was lower by 18.4...15.8...4.6 %, and in pumpkin fruits was higher by 17.5...4.6...26.8 %, in variants with pre-sowing seed treatment, respectively, in electric fields of constant, alternating and pulsed high voltages, compared to the control;

6) acidity in harvested watermelon fruits did not change in variants with pre-sowing seed treatment, respectively, in electric fields of constant, alternating and pulsed high voltages, compared to the control;

7) acidity in harvested pumpkin fruits increased by 10.3 % in variants with pre-sowing seed treatment in the electric field of constant and alternating high voltage, and decreased in the variant with treatment in the electric field of pulsed high voltage by 11.3 % compared to the control.

The conducted research and analysis of the obtained results allows to present some reasoning about the applicability of electrostimulation of seeds before sowing, including for melon crops, and the effectiveness of its application as an agro-technological operation. It is known that stimulating doses of external influence, without violating the basic programme of plant development, laid down in the genetic structure, accelerate only the implementation of this programme, which is expressed in a faster passage of ontogenesis stages. According to A.A. Zhuchenko, academician of the Russian Academy of Agricultural Sciences and the Russian Academy of Sciences, electric fields inhibit plant growth, increase respiration intensity, affect growth movements. Biological effects occurring after the impact of electric fields on plants are manifested in the acceleration of seedling growth, increase in female flowers, various growth anomalies, but to date, the available information is still insufficient to understand not only the nature but also the nature of the action of electromagnetic fields, including electric fields of different types and intensities.

Given the nutritional value of melon products, environmentally friendly methods of increasing yield and quality of products are necessary. And that is why, in our opinion, the presented results of the work and conclusions made on it are not only of research, but also of industrial interest, especially today, when the country has emphasised the course on organic farming, production of safe food and reducing the negative impact on the environment.

4 Conclusion

The conducted research on seed pre-sowing treatment in high voltage electric fields showed its positive effect, which was manifested in the following:

1. Pumpkin seeds treatment in the electric field of constant high voltage showed that on the 3rd day there were 100% of germinated seeds, in the electric field of variable high voltage – 50%, in the electric field of pulsed high voltage – 30%, control – 1%; pumpkin seedling in the treatment in the electric field of constant high voltage was longer in 9.0 and 3.6 times than in the control and other treatments; treatment of watermelon seeds in the electric field of constant high voltage showed that on the 3rd day there were 70% of germinated seeds, in the electric field of variable high voltage – 20%, in the electric field of pulsed high voltage – 40%, the control germinated watermelon seeds did not show; watermelon sprout at treatment of seeds in the electric field of constant high voltage was longer in 1,5... 2,0 times than at other treatments; watermelon sprout at treatment of seeds in the electric field of constant high voltage was 1,5...2,0 times longer than at other treatments.2.0 times longer than in other treatments, no seedlings were observed in the control.
2. High effect on destruction of pathogenic microorganisms was observed: when seeds were treated in the electric field of pulsed high voltage – the number of pathogenic microorganisms on the shell of watermelon and pumpkin seeds was 4.25 and 4.1 times lower compared to the control; when treated in the electric field of constant high voltage, their number was also 3.0 times lower, but treatment of seeds in the electric field of alternating high voltage recorded some stimulating effect – there was an increase in pathogenic microflora in 2.0
3. The analysis of the harvested yield allows us to say that the highest yield of watermelon and pumpkin was obtained with pre-sowing seed treatment in the electric field of constant high voltage, which was 25.5 and 37.8 % more than in the control; with treatment in the electric field of alternating high voltage – by 15.7 and 27.0 % more than in the control; in the electric field of pulsed high voltage – by 9.8 and 5.4 %.

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