Bulgarian Journal of Agricultural Science, 31 (No 5) 2025, 976–982

Effect of presowing electromagnetic treatments on long-term stored cotton seeds

Minka Koleva

Agricultural Academy, Field Crops Institute, 6200, Chirpan, Sofia, Bulgaria
Corresponding author: m_koleva2006@abv.bg

Abstract

Koleva, M., (2025). Effect of presowing electromagnetic treatments on long-term stored cotton seeds. *Bulg. J. Agric. Sci., 31*(5), 976–982

A three-step electromagnetic treatment was used for ecologically clean improvement of the laboratory sowing qualities of cotton seeds of the Helius cultivars, which had been stored for several years. It was found that when treating the seeds with initial values of the controllable factors: $U_4 = 6$ kV and $\tau_4 = 5$ s, all seeds, regardless of how many years they were stored before being treated in an electromagnetic field, reacted positively and had increased values of the observed indicators. In addition, after one year of storage, the total masses of root and sprout ($m_{root} + m_{sprout}$) = 138.4%/C were found to be equal to the total lengths of root and sprout $\ell_{root} + \ell_{sprout} = 140.3\%$/C. These values are comparable to the results obtained after pre-sowing treatments, according to options 1 (with initial $U_1 = 8$ kV and $_1 = 15$ s) and 2 (with initial $U_1 = 6$ kV and $_1 = 15$ s). To comply with the safety technique and increase the productivity in the pre-sowing electromagnetic treatments of cotton seeds, regardless of their storage period, a three-stage electromagnetic treatment of cotton seeds, the cultivar Helius, with the following step values of the controllable factors is recommended: $U_1 = 6$ kV and $\tau_1 = 5$ s, $U_2 = 4.5$ kV and $\tau_2 = 15$ s, $U_3 = 3$ kV and $\tau_3 = 25$ s. Pre-sowing electromagnetic treatments are an environmentally friendly way to both increase the laboratory parameters of cotton seeds and preserve the viability of some cotton varieties.

Keywords: cotton seeds; the cultivar Helius; laboratory parameters; pre-sowing electromagnetic treatments

Introduction

Cotton is of particular importance in the life of modern man. In Stoilova et al. (2016), the characteristics of the newly created Bulgarian cotton varieties are described. The book shows the high quality of Bulgarian cotton.

To increase cotton yields, non-traditional methods are already being used, such as pre-sowing treatments of seeds with various radiations in electric, magnetic, and electromagnetic fields.

In Bulgaria, large-scale studies have been conducted on the effects of pre-sowing electromagnetic treatments on the laboratory and field parameters of cotton seeds (Palov et al., 2012a; Stoilova et al., 2012). The possibility of a pre-sowing electromagnetic impact on other crops, whose seeds are rich in fat, has been investigated (Palov et al., 2012b). Pre-sowing treatments of fat-rich seeds were carried out in a chamber with flat electrodes (Sirakov, 2020a).

The beneficial effects of pre-sowing electromagnetic treatments have also been observed on cereal seeds, including wheat (Kostov et al., 2014) and corn (Sirakov and Mihaylov, 2022).

Research on pre-sowing electromagnetic treatments for triticale seeds has been conducted with international participation (Sirakov et al., 2021) and others.

The analysis of the results obtained from pre-sowing electromagnetic treatments shows that, from an ecological perspective, it is possible to stimulate the seeds of various crops to accelerate their growth and subsequently increase yields.

This study aimed to determine the laboratory parameters of cotton seeds, the cultivar Helius, treated in an electromagnetic field, after their long-term storage.

Materials and Methods

Cotton seeds of the cultivar Helius were used for this study. This cultivar was created at the Field Crops Institute in Chirpan through experimental mutagenesis, involving the irradiation of seeds with gamma rays. The cultivar Helius is characterized by early maturity, high productivity, large bolls, a high lint percentage, and medium-length fiber, which is very strong (Valkova, 2009).

In the state variety trial, the cultivar Helius achieved a seed cotton yield of 2810 kg ha^{-1}, exceeding the standard cultivars Chirpan-539 and Avangard-264 by 8.4%. The realized September yield was approximately 1780 kg ha^{-1}. It exceeded the standard cultivar Chirpan-539 by 9.9% (Stoilova et al., 2016). At maturity, its bolls open strongly and are suitable for mechanized harvesting. The described characteristics of cultivar Helius make it preferable for studies with pre-sowing electromagnetic treatments of seeds. The special thing here is that the seeds to be subjected to pre-sowing electromagnetic impact were stored for periods of three, two, and one year from their harvesting to the pre-sowing treatment.

Pre-sowing electromagnetic treatment was performed using the method described by Palov et al. (1995) in a complete factorial experiment (CFE) 2^2 (Mitkov and Minkov, 1993). Seeds for treating are placed in a chamber with flat electrodes. Following several studies on the electric field in the chamber (Sirakov, 2020a), its construction was optimized (Sirakov, 2020b). The seeds, located between the flat electrodes of the chamber, are subjected to a three-fold impact of the electromagnetic field by the so-called three-step treatment. For this purpose, with each subsequent impact, the value of the used high alternating voltage U, kV, supplied to the electrodes of the working chamber is reduced, while the treatment duration τ (s) is increased.

The pre-sowing treatment of seeds, from the three storage periods, was carried out in one day, according to the experimental planning matrix presented in Table 1.

According to Table 1, seed treatment was performed in three steps: I, II, and III. Additionally, treatment options 1 through 4 are from CFE 2^2. Control (untreated) seeds were used (the Control variant in Table 1) to establish the effect of pre-sowing impact.

The laboratory tests were carried out in a thermostat at a temperature of 25°C and a relative humidity of 95% (BDS 715-74). The following indicators were recorded: germination energy (%), germination (%), length (mm), and mass (g) of sprouts and roots, total length (mm), and mass (g) of sprouts and roots. After establishing the laboratory test results, the data from the corresponding observation were averaged and expressed as a percentage compared to the control (%/C).

A regression analysis was performed on the obtained results. Data were processed using the appropriate mathematical methods as described in Mitkov and Minkov (1993).

Results and Discussion

In graphical form, the research results of germination energy (g.e.) and germination (g.), in %/C (percentage to the control), for the seeds of the cultivar Helius, stored 3, 2 and 1 years, respectively, from their harvesting to their pre-sowing electromagnetic treatment are shown in Fig. 1. and Fig. 2.

Analysis of the obtained results shows that after a three-year stay, the control seeds had an average germination rate of 39.39% and a germination percentage of 42.26%.

From Fig. 1, it can be stated that after pre-sowing electromagnetic treatment according to option one from Table 1

Table 1. Matrix for planning the experiment in pre-sowing electromagnetic treatment of cotton seeds, the cultivar Helius

Treatment Option	Processing Steps											
	I				II				III			
	Controllable Factors				Controllable Factors				Controllable Factors			
	U_1		τ_1		U_2		τ_2		U_3		τ_3	
	Level	кV	Level	s	Level	кV	Level	s	Level	кV	Level	s
1	+1	8	+1	15	+1	6,5	+1	25	+1	5	+1	35
2	-1	6	+1	15	-1	4,5	+1	25	-1	3	+1	35
3	+1	8	-1	5	+1	6,5	-1	15	+1	5	-1	25
4	-1	6	-1	5	-1	4,5	-1	15	-1	3	-1	25
Control	Untreated seeds (control)											

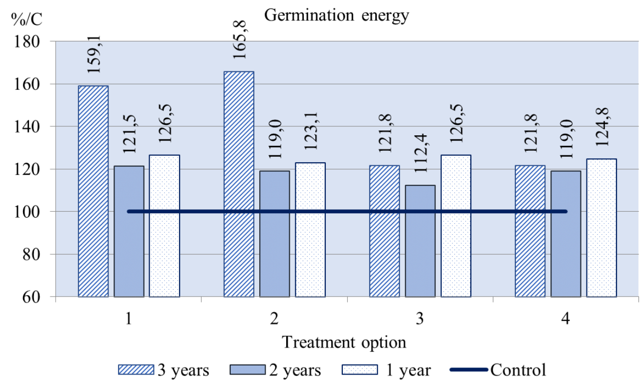

Fig. 1. Results of the germination energy test, in %/C, of cotton seeds, the cultivar Helius,after pre-sowing electromagnetic treatment

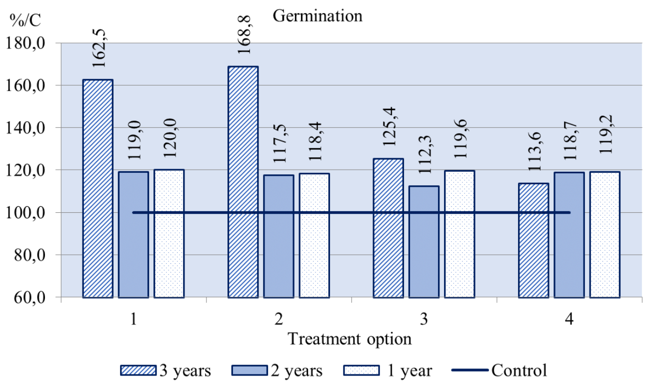

Fig. 2. Results of the germination test, in %/C, of cotton seeds, the cultivar Helius, after pre-sowing electromagnetic treatment

(with initial U_1 = 8 kV and τ_1 =15 s) and according to option 2 (with initial U_2 = 6 kV and τ_2 = 15 s), g.e. of the seeds stored for 3 years until their treatment increased to 159.08%/C and 165.8%/C, respectively.

For the same period of storage, after the pre-sowing electromagnetic treatment, the seed germination (Fig. 2) increased to 162.5/%KC (for variant 1 with initial U_1 = 8 kV and τ_1 = 15 s) and to 168.8 %/C (for option 2 with initial U_2 = 6 kV and τ_2=15 s), i.e., more than g.e.

For option 3 (with initial U_3= 8 kV and τ_3 = 5 s) and for option 4 (with initial U_4 = 6kV and τ_4 = 5s), seeds were stored for 3 years until their treatment showed germination (Fig. 2), respectively 125.4%/C and 113.6%/C, i.e., lower than that of treatment options 1 and 2.

The analysis of data on recorded germination suggests that, regarding the significantly increased germination, the treatment duration of 15 seconds is more dominant than the voltage used between the electrodes, specifically U_1 = 8 kV and U_2 = 6 kV.

In support of this assumption are the germination values indicated above for options 3 and 4, where the duration used was τ=5s.

Based on the achieved, after treatment, g.e. and g. The values of the seeds after 3 years of storage indicate that the impact of electromagnetic energy was unable to fully compensate for the loss of the seeds‘ genetic potential after their three-year storage.

In the seeds stored for 2 years before processing, the germination rate of the control dropped to 84.00%. After treatment according to var. 1, it reached 100%, indicating that all the seeds had germinated. Thus, the increase in germination compared to the control was 119.05%/K. Similar was the situation for the germination rate (120.00%/C) of the seeds stored for 1 year until their pre-sowing electromagnetic processing.

In treatment options 3 and 4, and in storage for 2 years and 1 year after seed harvesting, the pre-sowing electromagnetic energy helped to increase seed germination up to (99...100)%, or compared to the control, over 119%/C.

According to the obtained results of the laboratory tests, regression equations of the type were compiled (Mitkov and Minkov, 1993):

$$\hat{Y} = b_0 + b_1\dot{x}_1 + b_2\dot{x}_2 + b_{12}\dot{x}_1\dot{x}_2 \tag{1}$$

Where $\hat{Y}$ is the observed parameter, the coded value of the controllable factor, treatment voltage?

$\dot{x}_2$ – the coded value of the controllable factor treatment duration;

b_0 – the equation free term;

b_1, b_2 Moreover, b_{12} are the coefficients in front of the controllable factors?

According to (1) and the data obtained from the laboratory tests, the regression equations for g.e. (not shown here) and germination: equation (2) – for seed storage for three years (3 years), equation (3) – for storage for two years (2 years) and equation (4) – for one year storage (1 year).

$$\hat{Y}_{g.\ 3\,years} = 142{,}58 + 1{,}38\dot{x}_1 + 23{,}07\dot{x}_2 - 4{,}54\dot{x}_1\dot{x}_2 \tag{2}$$

$$\hat{Y}_{g.\ 2\,years} = 116{,}87 - 1{,}19\dot{x}_1 + 1{,}39\dot{x}_2 + 1{,}98\dot{x}_1\dot{x}_2 \tag{3}$$

$$\hat{Y}_{g.\ 1\,year} = 119{,}30 + 0{,}50\dot{x}_1 - 0{,}10\dot{x}_2 + 0{,}30\dot{x}_1\dot{x}_2 \tag{4}$$

The analysis of coefficients in equations (2)...(4) shows that for the seeds stored for 3 years – i.e., equation (2) –

pre-sowing electromagnetic treatment is highly effective. The sign "+" in front of the coefficient , as well as its value "23.07", means that for more effective processing, the duration of impact should be increased. This proves, in a mathematical way, the dominant importance of the influence of duration τ (s) of the pre-sowing electromagnetic treatment of the seeds.

The interaction between the two factors has a negative sign and a coefficient of "- 4.54". This shows that an optimum must be sought between the greater increase in the duration of the electromagnetic impact and the smaller increase in the voltage between electrodes of the working chamber.

The smaller value of 119.30 in (4) indicates that seeds have a normal genetic ability to germinate – they were produced in the previous year of treatment. The relatively small values of the coefficients b_1 (0.50) and b_2 (0.10) indicate that the magnitudes of the controllable treatment factors are correctly selected for seeds stored for one year from their production to their pre-sowing impact.

The averaged results of the study of length (ℓ) and mass (m) of roots and sprouts of cotton seeds, after pre-sowing electromagnetic treatment, in % compared to the control, are presented in Table 2.

Here it should be noted that the established average root lengths ℓ_{root}, in cm and their masses m_{root}, in g, of the control, (untreated) seeds are as follows: ℓ_{root} for 3 years of storage – 6.83 cm, for 2 years – 12.13 cm and for 1 year – 10.91 cm, and for their masses m_{root}, respectively: 0.08 g, 0.13 g and 0.11 g.

The data for the control seeds indicate a significantly reduced genetic potential of the seeds after 3 years of storage from production to treatment.

From the analysis of the data in Table 2, it can be observed that after the pre-sowing electromagnetic treatment, for some of the impact variants, there is a notable increase in root length per mass. Thus, for example, at one-year storage, for treatment option 2 (with initial values: U_1 = 6 kV and τ_1 = 15 s), the increases in root length and root mass *are* ℓ_{root} = 143.5%/C and m_{root} = 120.3%/C, respectively.

For the case, the anticipatory increase, after the pre-sowing electromagnetic treatment, of the length of the root (by 143.5% for variant 2) compared to its mass (120.3%) can be attributed to its thinning at its greater length reached. Production observations (not found a place here) show that subsequently this difference „disappears".

From Table 2, it can also be established that for 2 years of storage until seed treatment, both option 2 (with a reduced initial U_1 of 6 kV) and option 3 (with a reduced initial τ_1 = 5 s) had a suppressive effect. In it, the length of the root is only $\ell_{root\ =\ 82.6\%/C}$ for option two and $\ell_{root\ =\ 89.4\%/C}$ for option 3. Corresponding reductions were also found in the mass of roots – m_{root} =80.5%/C – for option two and m_{root} = 91.2%/C – for option 3.

The mentioned reductions can be attributed to the combination of reduced voltage values from 8 kV to 6 kV and the duration of impact, which decreased from 15 s to 5 s, along with the 2-year storage period from production to seed treatment.

The data from Table 2 also show that when the seeds were treated according to option 4 (with initial U4 = 6 kV and τ_4 = 5 s), all seeds, regardless of how many years they were stored before treatment in an electromagnetic field, reacted positively and had increased values of the observed indicators.

According to (1) and the data obtained from the laboratory studies, the regression equations were found for the total (united) masses m of roots and sprouts, and the total lengths ℓ of roots and shoots. For three years of seed storage, these are, respectively, equations (5 and 8), for two years of seed storage – equations (6 and 9), and for one year of seed storage – equations (7 and 10).

$$\hat{Y}_{m\ 3years} = 120{,}81 - 9{,}07\dot{x}_1 + 3{,}92\dot{x}_2 - 2{,}13\dot{x}_1\dot{x}_2 \qquad (5)$$

$$\hat{Y}_{m\ 2years} = 108{,}25 + 1{,}59\dot{x}_1 - 4{,}47\dot{x}_2 + 7{,}31\dot{x}_1\dot{x}_2 \qquad (6)$$

$$\hat{Y}_{m\ 1year} = 138{,}24 - 0{,}32\dot{x}_1 + 5{,}48\dot{x}_2 + 5{,}28\dot{x}_1\dot{x}_2 \qquad (7)$$

$$\hat{Y}_{\ell\ 3years} = 119{,}78 - 7{,}71\dot{x}_1 + 0{,}23\dot{x}_2 - 1{,}15\dot{x}_1\dot{x}_2 \qquad (8)$$

Table 2. Results of study of length and mass of roots and sprouts of cotton seeds, after pre-sowing electromagnetic treatment, in % compared to the control

Option	Roots						Sprouts					
	Length, %C			Mass, %C			Length, %C			Mass, %C		
	3 years	2 years	1 year	3 years	2 years	1 year	3 years	2 years	1 year	3 years	2 years	1 year
1	103.9	112.6	125.5	101.3	97.7	124.7	122.0	117.3	148.8	117.2	117.5	156.9
2	117.5	82.6	143.5	109.4	80.5	120.3	145.7	99.2	144.5	144.9	99.5	145.1
3	119.8	89.4	107.4	102.9	91.2	100.6	105.7	106.5	128.7	111.7	112.1	136.2
4	124.2	111.0	136.5	114.2	103.4	122.8	129.8	127.4	146.0	126.4	123.3	143.7

$$\hat{Y}_{\ell\,2years} = 104{,}17 + 1{,}07\dot{x}_1 - 2{,}58\dot{x}_2 + 11{,}76\dot{x}_1\dot{x}_2 \quad (9)$$

$$\hat{Y}_{\ell\,1year} = 133{,}70 - 8{,}39\dot{x}_1 + 5{,}62\dot{x}_2 + 3{,}84\dot{x}_1\dot{x}_2 \quad (10)$$

Equations (5) through (10) have been checked for adequacy and have significant coefficient values preceding the controllable factors, according to Mitkov and Minkov (1993).

The signs in front of the coefficients of equations (5) and (8) show that after three years of seed storage, the effect of the electromagnetic field on the combined masses m of the roots and sprouts, and the lengths ℓ of the roots and sprouts of seeds is of the same type. According to (5), this effect, at the same values of controllable factors, was more substantial on the mass of roots and sprouts, because in (5) all the coefficients before the coded values of the controllable factors have a greater value than the same in (8).

The "-" sign in front of the coefficient of the controllable factor $\dot{x}_1$ indicates that in order to increase the effect of the pre-sowing electromagnetic treatment, the value of the applied voltage should be reduced.

The impact of the electromagnetic field on the combined mass and lengths of roots of seeds after their two-year storage until treatment was of the same type – the coefficients in front of the factor $\dot{x}_1$ are respectively +1.59 for equation (6) and +1.07 for equation (9), and before the factor $\dot{x}_2$ are respectively -4.47 and -2.58.

The coefficients in front of the interactions in (6) and (9) have values of 7.31 and 11.76, respectively, for two years of seed storage, both with positive signs. This means that, if necessary, a more careful selection of the values of the controllable factors is needed.

The analysis of equations (7) and (10) shows that for future treatments of seeds produced in the previous year (i.e., stored for 1 year from production to treatment), the values of the controllable factors related to the electromagnetic impact should not be changed.

In graphical terms, the results of an examination of the averaged pooled masses ($m_{root} + m_{sprout}$) and lengths ($\ell_{root} + \ell_{sprout}$) of roots and sprouts of seeds (in %/C) of cotton cultivar Helius stored: three, two, and one years from their production to pre-sowing treatment are shown respectively in Fig. 3 and Fig. 4.

It should be noted that the established average, combined mass of root and sprout ($m_{root} + m_{sprout}$) of the control (untreated) seeds was as follows: for 3 years of storage – 0.30 g, for 2 years of storage – 0.53 g, and 1 year of storage – 0.41 g.

The established average, combined root and sprout lengths ($\ell_{root} + \ell_{sprout}$) of the control seeds were: for 3 years of storage – 11.78 cm, for 2 years of storage – 19.87 cm, and for 1 year of storage – 18.14 cm.

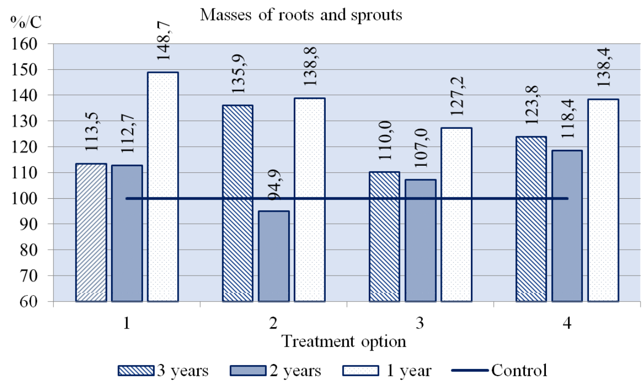

Fig. 3. Effect of pre-sowing electromagnetic treatment on the average combined masses of roots and sprouts, of the studied plants, in %/C

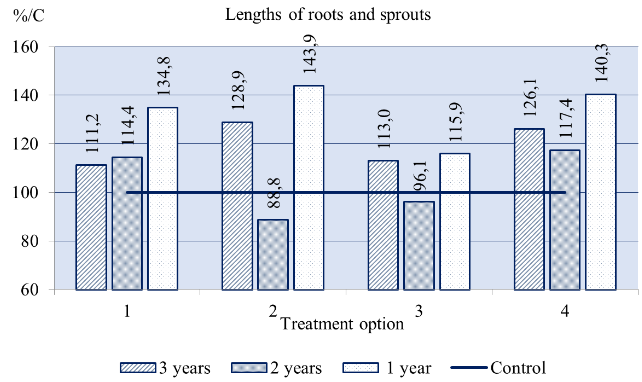

Fig. 4. Effect of pre-sowing electromagnetic treatment on the averaged combined lengths of roots and sprouts of the studied plants, in %/C

The above data show that at three years of seed storage, their combined root and sprout masses ($m_{root} + m_{sprout}$) and root and sprout lengths ($\ell_{root} + \ell_{sprout}$) were significantly smaller in absolute values than the same for the remaining years of storage.

After three years of storage and after the pre-sowing treatment according to option 2 (with initial: U_1 = 6 kV and τ_1 = 15 s), the combined masses of root and sprout ($m_{root} + m_{sprout}$) increased to 135.9%/C, and the combined root and sprout lengths ($\ell_{root} + \ell_{sprout}$) – up to 128.9%/C.

After one-year storage and after the pre-sowing treatment according to option 1 (with initial: U_1 = 8kV and τ_1 = 15s), the combined root and sprout masses ($m_{root} + m_{sprout}$) increased to 148.7%/C, and the combined root lengths and sprout ($\ell_{root} + \ell_{sprout}$) – up to 134.8%/C.

Treatment according to variant 2 (with initial settings: $U_1 = 6$ kV and $\ell_1 = 15$ s) led to an increase in ($m_{root} + m_{sprout}$) to 138.8%/C and in ($\ell_{root} + \ell_{sprout}$) to 143.9%/C.

From Fig. 3 and Fig. 4, it can be found that after 3-year storage period and when the treatment of seeds with values of the controllable factors of option 4 (with initial: $U_1 = 6$ kV and $\tau_1 = 5$ s), the combined masses of root and sprout have reached 123.8%/C, and those of root and shoot lengths – up to 126.1C%.

From the above, it can be concluded that at low values of the controllable factors, a leveled development of masses and lengths of roots and sprouts is obtained. The situation is almost the same with the other storage terms – 2 years and 1 year.

For example, with a storage period of 1 year and after the pre-sowing electromagnetic treatment of cotton seeds, the cultivar Helius achieved combined masses of root and sprout: $m_{root} + m_{sprout} = 138.4\%/C$ and of lengths $\ell_{root} + \ell_{sprout} = 140.3\%$ /C. These values are comparable to the results obtained after pre-sowing treatments according to options 1 (with initial $U_1 = 8$ kV and $\tau_1 = 15$ s) and 2 (with initial $U_1 = 6$ kV and $\tau_1 = 15$ s).

The analysis of the above data shows that it is more profitable to treat the seeds according to the values of the controllable factors of option 4, because the voltage between the electrodes is lower – $U_4 = 6$ kV is less than that used in the first treatment option $U_1 = 8$ kV. The smaller value of the voltage, $U_4 = 6$ kV, enables a safer technique in the pre-sowing electromagnetic treatment of seeds.

On the other hand, the treatment duration of variant 4 was $\tau_4 = 5$ s, which was three times less than the treatment duration of variant 1 – $\tau_1 = 15$ s. This can increase the productivity of pre-sowing electromagnetic treatments of cotton seeds.

The above reasoning also applies to seeds stored for 3 and 2 years before their pre-sowing treatment.

The results of the conducted research and their analysis show that pre-sowing electromagnetic treatments have a beneficial impact on the sowing qualities of Helius cotton seeds. Additionally, these treatments are ecologically clean and help stimulate and restore the germination qualities of seeds after a long period of storage.

Conclusion

It has been established that the pre-sowing electromagnetic impacts, known as the three-stapel electromagnetic treatment, help activate the sowing qualities of cotton seeds, cultivar Helius, stored for 3, 2, and 1 years prior to their treatment.

By examining control, untreated cotton seeds, the cultivar Helius, stored for 3 years, significantly reduced genetic potential was found, with their germination energy being in the range of (34...46)%, and germination – (37...49)%.

After pre-sowing electromagnetic treatment, the germination energy of three-year-old stored seeds increased from 121.8% to 165.8% and germination increased from 113.6% to 168.8%. However, the actual germination rate of these seeds remained low, at 68.67%. In this sense, the impact of electromagnetic energy, with the selected values of controllable factors, was unable to fully compensate for the loss of genetic capabilities in seeds after three years of storage.

Due to the high fat content, a three-stapel pre-sowing electromagnetic treatment of seeds was proposed with controllable factors: the voltage (U, kV) between the electrodes and the duration of the impact (s).

It has been established mathematically and experimentally that the duration τ, s of treatment was dominant in the pre-sowing electromagnetic treatment to increase the sowing qualities of cotton seeds.

When using impact with initial conditions: $U_1 = 6$ kV and $\tau_1 = 15$ s, it was found that the increase in length of the roots, ℓ_{root}, was 143.5%/C, compared to the increase in their mass, $m_{root,}$ which was 120.3%/C.

It was established that when the seed treatment was performed with initial values of the controllable factors according to option 4: $U_1 = 6$ kV and $\tau_1 = 5$ s, all seeds, regardless of how many years they had been stored before processing, reacted positively and showed increased values of the observed indicators. At the same time, after one year of storage, an equalization of the size of the total masses of root and sprout ($m_{root} + m_{sprout}$)=138.4%/C with the size of the total lengths of root and sprout $\ell_{root} + \ell_{sprout}$=140.3%/C was found. These values are comparable to the results obtained after pre-sowing electromagnetic treatments, according to options 1 (with initial settings: $U_1 = 8$ kV and $\tau_1 = 15$ s) and 2 (with initial settings: $U_1 = 6$ kV and $\tau_1 = 15$ s).

In order to observe the safety technique and increase the productivity in the pre-sowing electromagnetic treatments of cotton seeds, regardless of their storage period, a three-stage electromagnetic treatment of cotton seeds, the cultivar Helius, with the following values of the steps of the controllable factors is recommended: $U_1 = 6$ кV and $\tau_1 = 5$ s, $U_2 = 4.5$ кV and $\tau_2 = 15$ s, $U_3 = 3$ кV and $\tau_3 = 25$ s.

Pre-sowing electromagnetic treatments are an environmentally friendly way both to increase the laboratory parameters of cotton seeds and to preservation of viability of some cotton varieties.

References

BDS 715-74. Seeds from fiber crops – flax, hemp, cotton and hemp. Sowing qualities (Bg).

Kostov, K., Palov, Iv., Sirakov, K., Kuzmanov, E. & Zahariev, Sv. (2014). Effect of pre-sowing electric treatments of seeds on the yields of wheat varieties Enola and Kristy. *Bulg. J. Agric. Sci., 20*(6), 1526 – 1530.

Mitkov, D. & Minkov, D. (1993). Statistical methods for research and optimization of agricultural machinery. Parts I and II. Zemizdat, Sofia (Bg).

Palov, Iv., Stefanov, St., Ganev, Hr., Zlatev, Zl. & Stankovski, M. (1995). Method for pre-sowing electromagnetic treatment of peanut seeds. Patent for Invention, No. 42681, A 01 C 1/00, A 01 C 7/04.

Palov, Iv., Sirakov, K., Stoilova, A. & Radevska, M. (2012a). Effect of electromagnetic treatment and storage period on seed quality of cotton seeds. II. Length of primary root system – root and sprout. *Plant Sciences, 49*, 28 – 36 (Bg).

Palov, Iv., Kuzmanov, E., Sirakov, K., Stefanov, St. & Neykov, Y. (2012b). Results from a preliminary research on the pre-sowing electromagnetic treatment of rape seeds. *Agronomy Research, 10*(1-2), 335 – 340.

Sirakov, K. (2020**a).** Study on the electric field between the electrodes of a chamber for pre-sowing treatment of seeds. *7th International Conference on Energy Efficiency and Agricultural Engineering (EE&AE),* Ruse, Bulgaria, 1-3.

Sirakov, K. (2020b). Optimization of the design of a chamber for pre-sowing treatment of seeds. *7th International Conference on Energy Efficiency and Agricultural Engineering (EE&AE),* Ruse, Bulgaria, 1-3.

Sirakov, K., Álvarez, J. & Muhova, A. (2021). Evaluation of the effect of electromagnetic treatment on the sowing qualities of triticale seeds. *Bulg. J. Agric. Sci., 27*(4), 699 – 711.

Sirakov, K. & Mihaylov, M. (2022). Influence of pre-sowing electromagnetic and chemical treatment on sowing qualities of maize seeds. 8th International Conference on Energy Efficiency and Agricultural Engineering (EE&AE), Ruse, Bulgaria, 1-5.

Stoilova, A., Radevska, M., Sirakov, K. & Palov, Iv. (2012). Effect of electromagnetic treatment and storage period on sowing qualities of cotton seeds. III. Mass of primary root system – root and sprout. *Plant Sciences*, *49*, 37 – 45 (Bg).

Stoilova, A., Valkova, N., Saldzhiev, Iv. & Bozhinnov, M. (2016). New cotton varieties – economic and biological characteristics. Academic Publishing House of Agrarian University, Plovdiv. (Bg)

Valkova, N. (2009). Helius and Trakia – new cotton varieties. *Field Crop Studies*, *1*(1), 131 – 135 (Bg).

Received: **March, 12, 2024**; *Approved*: **April, 10, 2024;** *Published:* **October, 2025**