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Laboratory Tests on the Sowing Qualities of Cotton Seeds of the Variety Helius, After Their Pre-Sowing Electromagnetic Treatment

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GOAL OF THE STUDY

Pre-sowing electromagnetic treatments can help reduce the use of synthetic fertilisers [3,4,5], while contributing to the optimisation of yields within established agronomical practices. A considerable amount of research indicates that the excessive use of synthetic fertilisers leads to serious contamination of the soil environment and agricultural produce [1].

At the Angel Kanchev University of Ruse and at the Field Crops Institute of Chirpan, numerous studies are conducted involving pre-sowing electromagnetic treatments of seeds of various agricultural crops, including cotton.

It has been scientifically proven [6,7,8] that during and after the application of pre-sowing electromagnetic treatments, specific biophysical and biochemical changes occur in the seeds, which contribute to improved plant growth and fruiting. In a broader sense, when these treatments are carried out under optimally set values of the experimental factors, they exert a stimulating effect on the vegetative development of crops.

Depending on the values of the experimental factors of exposure, both positive and negative results of the treatment of seeds have been observed.

The parameters of pre-sowing treatment have been established for seeds of wheat [9], triticale [10], maize [11] and other crops.

Cotton seeds are rich in oils. Therefore, their pre-sowing treatments were performed in a chamber with plane electrodes [12,13].

The aim of the study was to investigate the effect of pre-sowing electromagnetic treatments on the germination vigor (g.v.) and laboratory germination percentage (g.) of cotton seeds of the variety 'Helius', and to analyse their resulting response curves.

METHODOLOGY OF THE INVESTIGATION

For the purposes of the pre-sowing electromagnetic treatments, a method was applied involving a periodic decrease of the voltage U between the electrodes of the working chamber and increase in the duration of exposure [13].

The experimental factors of exposure were: the elevated voltage U, kV, supplied to the electrodes; the duration of the exposure τ, s; and the storage period from treatment to sowing T, days.

To compare and assess the effect of the electromagnetic treatment, a portion of the seeds was left untreated, i.e. served as the control batch.

The values of the experimental factors and their corresponding variation levels are presented in Table I. These values have been determined in accordance with our previous research work [16,17,18].

Table 1. Values of the experimental factors and their corresponding variation levels in the pre-sowing electromagnetic treatments of cotton seeds of the variety „Helius"

Treatment Variant	Experimental Factors													
	U_i, $(\hat{x}_1)$; τ_i, $(\hat{x}_2)$												T, $(\hat{x}_3)$	
	Processing Steps													
	I				II				III				Level	Days
	Experimental Factors				Experimental Factors				Experimental Factors					
	U_1		τ_1		U_2		τ_2		U_3		τ_3			
	Level,	kV	Level	s	Level	kV	Level	s	Level	kV	Level	s		
1	1	8	1	15	1	6.5	1	25	1	5	1	35	1	21
2	-1	6	1	15	-1	4.5	1	25	-1	3	1	35	1	21
3	1	8	-1	5	1	6.5	-1	15	1	5	-1	25	1	21
4	-1	6	-1	5	-1	4.5	-1	15	-1	3	-1	25	1	21
5	1	8	1	15	1	6.5	1	25	1	5	1	35	-1	7
6	-1	6	1	15	-1	4.5	1	25	-1	3	1	35	-1	7
7	1	8	-1	5	1	6.5	-1	15	1	5	-1	25	-1	7
8	-1	6	-1	5	-1	4.5	-1	15	-1	3	-1	25	-1	7
9	1	8	0	10	1	6.5	0	20	1	5	0	30	0	14
10	-1	6	0	10	-1	4.5	0	20	-1	3	0	30	0	14
11	0	7	1	15	0	5.5	1	25	0	4	1	35	0	14
12	0	7	-1	5	0	5.5	-1	15	0	4	-1	25	0	14
13	0	7	0	10	0	5.5	0	20	0	4	0	30	1	21
14	0	7	0	10	0	5.5	0	20	0	4	0	30	-1	7
C	Control (untreated seeds)													

MAIN RESULTS FROM THE STUDY

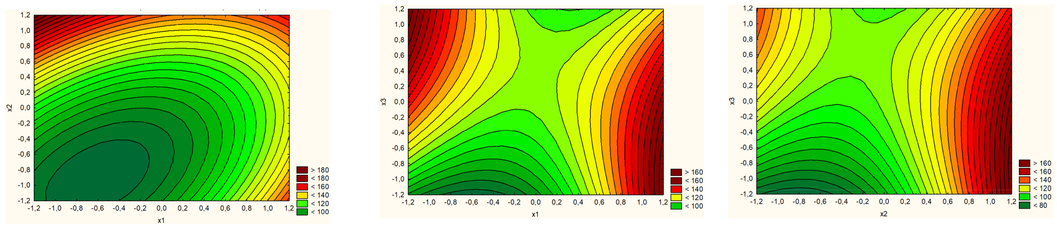
A. Analysis of the equation for the laboratory germination vigor

$$\hat{Y}_{g.v.} = 101.389 + 6.667\,\hat{x}_1 + 22.222\,\hat{x}_2 + 6.667\,\hat{x}_3 - 16.167\,\hat{x}_1\hat{x}_2 - 19.444\,\hat{x}_1\hat{x}_3 - 16.667\,\hat{x}_2\hat{x}_3 + 20.833\,\hat{x}_1^2 + 20.833\,\hat{x}_2^2 - 12.500\,\hat{x}_3^2$$

From the equation it may be observed that the impact of the two experimental factors — voltage U and storage period T is equivalent, as their coefficients before the coded values are identical: 6.667. However, the impact of the duration of exposure τ is considerable – b_2=22.222.

For a detailed analysis of the effect of pre-sowing electromagnetic treatments on plant development, the response curves (Fig.1) for each pair of experimental factors are constructed using the STATISTICA software. The levels of variation of the studied parameter at different values of the experimental factors are indicated in different colours.

The analysis of the results of the laboratory tests as well as the graphs in Fig.1 shows that, in order to stimulate higher germination vigor of the seeds, the values of the experimental factors should be increased. In this case, the maximum values of the experimental factors at the first level were, respectively: U_1 =8 kV, τ_1=15 s and T= 21 days.



a) b) c)

Fig.1. Response curves of seed germination vigor as a function of the coded values of the experimental factors

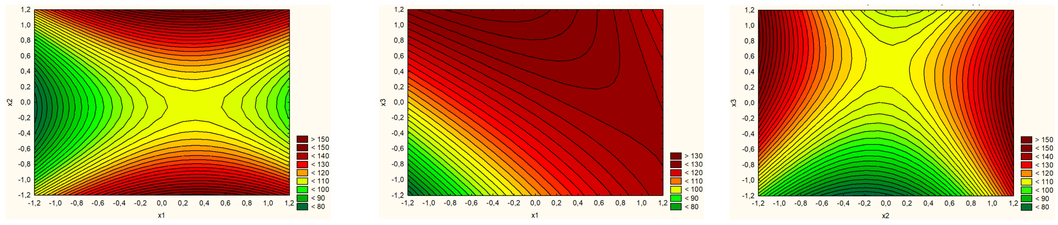
B. Analysis of the equation for laboratory germination percentage

$$\hat{Y}_{g.} = 113.021 + 9.167\,\hat{x}_1 + 2.500\,\hat{x}_2 + 11.667\,\hat{x}_3 - 1.042\,\hat{x}_1\hat{x}_2 - 11.458\,\hat{x}_1\hat{x}_3 - 7.292\,\hat{x}_2\hat{x}_3 - 13.021\,\hat{x}_1^2 + 28.646\,\hat{x}_2^2 - 8.854\,\hat{x}_3^2$$

From the equation it may be observed that if the values of all experimental factors of the pre-sowing treatment are set at their medium level, then the value of the coefficient b_0 will be b_0=113.021.

The analysis shows that an increase in the germination percentage of the seeds could be achieved if the storage period T from pre-sowing treatment to sowing is increased – here the coefficient before the coded value of the factor is b_3=11.667.

The value of coefficient b_1 is smaller compared with coefficient b_3: b_1=9.167. Therefore, the required increase in the treatment voltage U is smaller.



a) b) c)

Fig.2. Response curves of seed germination percentage as a function of the coded values of the experimental factors

CONCLUSIONS

Through a three-factor experiment based on an optimal composite design of the type B_3, three-step pre-sowing electromagnetic treatments were carried out of cotton seeds of the variety 'Helius'.

In the laboratory tests, the following responses were observed: germination vigor and germination percentage of the seeds. From the results obtained, the coefficients of the regression model were calculated, the necessary statistical tests were performed, and the response curves were plotted for each pair of responses.

When seeds were treated using the high levels of the experimental factors, with the values at the first step being U=8 kV, τ=15 s and T=21 days (variant 1), the treatment had a stimulating effect, with the observed responses exceeding those of the control seeds as follows: germination vigor – 122.2%/C; germination percentage – 125.0%/C.

When using (variant 2) the voltage at its low level U=6 kV, with the other experimental factors at their high level τ=15s and T=21 days, the treatment also had a stimulating effect, with the observed responses exceeding those of the control seeds as follows: germination vigor – 166.7%/C; germination percentage – 133.3%/C.

When seeds were treated with experimental factors set at their low levels (variant 8), the pre-sowing electromagnetic treatment had an inhibitory effect: germination vigor – 33.3%/C, germination percentage – 75.0%/C.

The study of the effect of pre-sowing electromagnetic treatment on the sowing qualities of cotton seeds of the variety 'Helius' can be extended through laboratory tests on the lengths and masses of the shoots and roots of the plants.