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Effect of Pre-Sowing Electromagnetic Treatments on the Length and Mass of Sprouts and Roots of Cotton Plants of the Cotton Variety „Helius“

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GOAL OF THE STUDY

At present, the increase in yields of agricultural crops is achieved through strong intensification of production, with extensive use of chemicals [1] and high input costs. This results in high yields, but the environmental purity of the produce and the soil [2] is endangered. Of great importance for modern agriculture is the search for alternative, environmentally friendly methods and technologies for increasing the yields of major agricultural crops with low energy demand.

An important element in cotton cultivation technology is the use of high-quality sowing material [3,4]. Seeds are the main reproductive structure of the plant, and the realisation of the yield and quality potential of the variety can be largely stimulated by appropriate pre-sowing treatment in physical fields [5,6,7]. In the studies of pre-sowing seed treatment in magnetic fields, permanent magnets [8,9] and electromagnets [10,11] generating fields with constant intensity, pulsed magnetic fields [12,13], or low-frequency alternating magnetic fields [14] are used.

At Angel Kanchev University of Ruse numerous studies are being conducted on the effect of various pre-sowing electromagnetic treatments on the development of plants from crops with high oil content [15,16].

The results of seed treatment depend on the values of the experimental factors of exposure. Both positive and negative effects have been observed.

The aim of the study is to investigate the effect of pre-sowing electromagnetic treatments on the length and mass of sprouts and the length and mass of roots of cotton seeds of the variety ‘Helius’.

METHODOLOGY OF THE INVESTIGATION

The objects of the study were the length and mass of sprouts and roots of cotton seeds of the variety ‘Helius’ [17].

Cotton seeds are rich in oils. Therefore, for their pre-sowing treatment, a method was used involving a periodic decrease in the values of the voltage U between the electrodes of the working chamber and increase in the duration of exposure [18]. The treatment itself was carried out in a special, optimised working chamber.

The treatment of the seeds was performed according to an optimal composite design of the type B_3 [19]. The experimental factors of exposure were: the increased voltage U, kV, applied to the electrodes; the duration of exposure τ, s; and the storage period of the seeds before sowing T, days. These were selected in accordance with [16].

The values of the experimental factors and their corresponding levels of variation are shown in Table I. [16]. Untreated cotton seeds (control) were used for comparison of the results. The values of the parameters from the different treatment variants were recalculated relative to the corresponding controls.

For each treatment variant, three replications were set in a thermostat under controlled conditions [16]. Measurement of the lengths and masses of sprouts and roots was carried out on the seventh day. All results from the tests were statistically processed and expressed as a percentage relative to the controls (untreated seeds).

MAIN RESULTS FROM THE STUDY

A. Analysis of the equations obtained for length and mass of sprouts

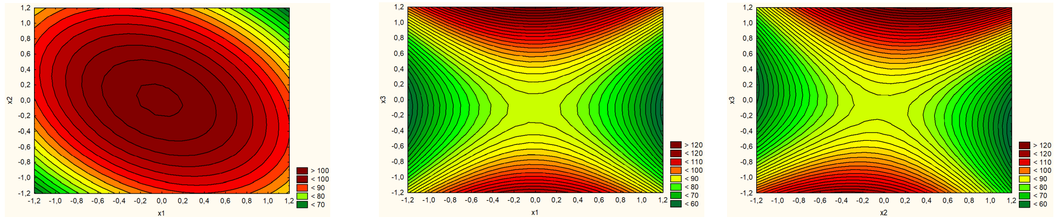
Using the research data, the equation for the sprout length ℓspr. and the equation for the sprout mass $m_{spr.}$ were compiled.

$$\hat{Y}_{\ell_{spr.}} = 91{,}609 - 0{,}440\,\hat{x}_1 - 0{,}069\,\hat{x}_2 + 5{,}278\,\hat{x}_3 - 5{,}903\,\hat{x}_1\,\hat{x}_2 + 0{,}347\,\hat{x}_1\,\hat{x}_3 + 11{,}111\,\hat{x}_2\,\hat{x}_3 - 15{,}567\,\hat{x}_1^2 - 16{,}030\,\hat{x}_2^2 + 28{,}067\,\hat{x}_3^2$$

$$\hat{Y}_{m_{spr.}} = 106{,}095 + 6{,}398\,\hat{x}_1 + 0{,}621\,\hat{x}_2 + 12{,}671\,\hat{x}_3 - 14{,}053\,\hat{x}_1\,\hat{x}_2 - 13{,}432\,\hat{x}_1\,\hat{x}_3 + 8{,}618\,\hat{x}_2\,\hat{x}_3 - 19{,}138\,\hat{x}_1^2 + 6{,}017\,\hat{x}_2^2 + 16{,}576\,\hat{x}_3^2$$

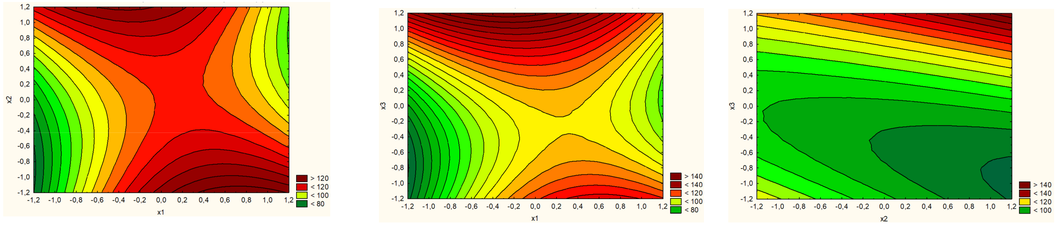
The response curves for the length and mass of sprouts are shown in Fig.1 and Fig.2, respectively. The considerations described regarding the reactions of the grown sprouts after the pre-sowing treatment of the seeds are confirmed by their response curves.

The response curves for sprout length – Fig.1.a – provide the possibility of a wider range of variation of the applied voltage U and duration of exposure τ, with the aim of obtaining optimal results from the pre-sowing electromagnetic treatment.



a) b) c)

Fig.1. Response curves length of seed sprouts as a function of the coded values of the experimental factors



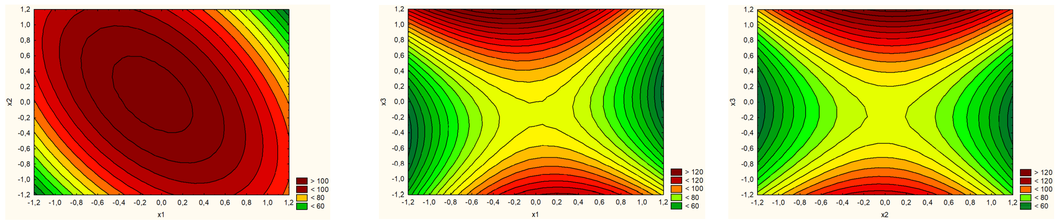
a) b) c)

Fig.2. Response curves mass of seed sprouts as a function of the coded values of the experimental factors

B. Analysis of the equations obtained for the length and mass of roots

$$\hat{Y}_{\ell_{root}} = 94{,}411 - 1{,}601\,\hat{x}_1 + 0{,}922\,\hat{x}_2 + 7{,}870\,\hat{x}_3 - 12{,}424\,\hat{x}_1\,\hat{x}_2 - 11{,}594\,\hat{x}_1\,\hat{x}_3 + 2{,}795\,\hat{x}_2\,\hat{x}_3 - 23{,}565\,\hat{x}_1^2 - 16{,}541\,\hat{x}_2^2 + 29{,}532\,\hat{x}_3^2$$

$$\hat{Y}_{m_{root}} = 101{,}255 + 4{,}200\,\hat{x}_1 + 4{,}841\,\hat{x}_2 + 14{,}841\,\hat{x}_3 - 15{,}298\,\hat{x}_1\,\hat{x}_2 - 12{,}558\,\hat{x}_1\,\hat{x}_3 + 3{,}654\,\hat{x}_2\,\hat{x}_3 - 24{,}543\,\hat{x}_1^2 + 9{,}704\,\hat{x}_2^2 + 15{,}868\,\hat{x}_3^2$$



a) b) c)

Fig.3. Response curves length of seed roots as a function of the coded values of the experimental factors

The analysis of Fig.1 – for sprout length, and Fig.3 – for root length, shows a uniformity in their nature, i.e. the selected values of the experimental factors of treatment influence the development of the length of seed sprouts and roots in the same way.

A more detailed examination of these figures makes it possible to select the values of the experimental factors that will contribute to uniform positive results from the pre-sowing treatment of the seeds.

CONCLUSIONS

According to plan B_3 three-step pre-sowing electromagnetic treatments were carried out on seeds of the cotton variety „Helius“. The measured laboratory parameters were the lengths and masses of sprouts, as well as the lengths and masses of roots of the plants. Regression equations were calculated for the respective parameters. The effect of the individual parameters was analysed by means of their response curves.

When seeds were treated with experimental factors at their high levels, where the values of the first step were U_1=8 kV, τ_1=15 s and T=21 days (variant 1), the treatment had a stimulating effect, with the observed responses being greater than those of the control seeds, respectively: sprout length ($\ell_{spr.}$) – 111.3%/C, sprout mass ($m_{spr.}$), - 122.4%/C, root mass m_{root}- 109.6%/C, which shows that they were better developed than the controls, although their length was (ℓ_{root}) – 73.9%/C.

In variant 2, where the treatment voltage was at its low level U_1=6 kV, and the other experimental factors were at their high level τ_1=15 s and T=21 days the treatment also had a stimulating effect, with the observed responses being greater than those of the control seeds: sprout length ($\ell_{spr.}$) – 107.2%/C, sprout mass ($m_{spr.}$) - 155.9%/C, root length (ℓ_{root}) – 118.3%/C and root mass m_{root} - 157.5%/C, respectively.

When seeds were treated with experimental factors at their low levels (variant 8), an inhibitory pre-sowing electromagnetic effect was obtained: sprout length ($\ell_{spr.}$) – 75.9%/C, sprout mass ($m_{spr.}$) - 59.0%/C, root length (ℓ_{root}) – 51.4%/C and root mass m_{root} - 46.6%/C.

On the basis of the results obtained from the laboratory experiments, the derived mathematical equations, and the response curves, further studies should be conducted in order to optimise the values of the experimental factors used in the electromagnetic pre-sowing treatment of cotton seeds of the variety ‘Helius’.