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The Effect of Low-Frequency EMI in Laboratory Conditions on Some Physiological Properties of Varieties and Lines of Plants Grown Under Two Different (Normal and Water Deficit) Conditions

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Abstract: There are a number of methods for evaluating drought tolerance of plants. One of them is based on the cultivation of seeds in sucrose solutions with high osmotic pressure to simulate physiological water deficit. By determining the percentage (%) of germinated seeds in solutions with high osmotic pressure, it is possible to determine the relative resistance of varieties to drought at the germination stage.

Key words: Effect of EMI, variety, line, chlorophyll content in seed leaves.

Introduction. In all cotton-growing countries of the world, water shortage is one of the abiotic factors that have a negative effect on productivity, and along with the selection of varieties that are resistant to these factors, scientific research is being conducted to control the physiological processes in plants. In this regard, special attention is paid to the use of electromagnetic impulses (EMI) as a factor that accelerates the growth and development of plants during the treatment of seeds of various plants before sowing.

It is known that stress (hardening) of seeds before planting increases the resistance of plants to various negative environmental factors [1]. Electromagnetic field (EMF) treatment of cotton seed prior to planting has been shown to increase plant resistance to salinity [2] and wilt [3]. The purpose of this chapter is to investigate the effect of EMF pre-planting treatment of cotton seeds on plant tolerance to moisture deficit at early stages of development.

Plant resistance to water deficit in the developmental stage is assessed from the rate of development (plant height, number and size of joints, intensity of transpiration, etc.) under normal and water deficit conditions.

Table 1 below shows the seed germination of lines and cultivars grown in different sucrose solutions with different osmotic pressures.

It is known from the indicators given in the table that the order of the lines and varieties selected as starting material in terms of drought resistance is as follows: S-6524→L-492→AN-Bayaut-2→L-

4112→Vodiy-28→L-608→Bogdod. The percentage of seed germination of experimental variant plants obtained from exposure of seeds to EMI was higher in all cases compared to the percentage of control variant plants. Therefore, low-frequency EMI treatment of the seeds of the research lines and cultivars can increase their drought resistance.

Table 1. Seed germination of cotton lines and cultivars exposed to pre-sowing EMI in sucrose solutions with different osmotic pressures simulating moisture deficiency

The object of the research	Variant	Germination of seeds, %					
		Concentration of sucrose					
		water	0,3 M 8 bar	0,5 M 14 bar	0,6 M 18 bar	0,7 M 22 bar	0,8 M 26 bar
S-6524	C	82,3±2,4	70,4±2,6	61,5±2,5	45,4±2,5	23,7±2,8	5,5±1,6
	E	90,3±3,2	88,1±3,3	82,4±3,4	68,7±3,5	42,1±3,2	22,3±3,3
L-492	C	89,1±2,9	85,3±2,4	78,4±4,3	52,5±4,2	18,5±4,6	2,4±0,4
	E	93,4±3,8	90,6±3,5	85,4±4,3	70,2±5,3	30,3±2,4	13,6±2,4
AN-Bayaut-	C	98,4±1,5	89,3±4,5	80,2±3,5	63,2±4,7	13,7±2,3	2,0±0,3
	E	95,4±2,6	92,8±4,3	88,2±3,2	72,2±4,6	28,6±3,2	8,4±1,7
L-4112	C	96,2±4,4	89,3±4,2	61,4±4,1	22,5±2,3	7,9±1,3	0
	E	97,1±3,2	92,4±3,2	78,4±3,8	52,6±3,4	25,3±2,7	5,3±1,5
Vodiy-28	C	92,3±2,7	85,4±4,5	53,5±4,4	18,8±2,8	4,1±0,8	0
	E	95,5±3,8	90,4±4,2	72,4±4,1	33,3±2,8	20,3±2,5	4,2±1,2
L-608	C	94,7±4,6	83,3±4,6	34,7±2,8	10,5±1,8	0	0
	E	94,5±4,7	91,5±4,2	62,6±3,7	25,4±2,1	3,2±1,2	0
Bogdod	C	99,3±3,6	82,3±3,2	55,4±4,8	6,2±1,5	0	0
	E	98,4±4,5	93,4±4,5	72,7±3,4	15,7±2,1	0	0

Note: C-control; E-experiment.

Physiological characteristics of water exchange of seedling leaves of 15-day-old seedlings can serve as an indicator of their drought resistance, therefore, the influence of these characteristics was studied under optimal (daily watering) and insufficient (daily watering) water supply in laboratory conditions. The experiments were carried out on the most drought-resistant: S-6524, Khorezm-150, and the least resistant, Namangan 77 and Farovon cotton varieties. Table 2 shows the results of these experiments.

Table 2. Indicators of water exchange in 15-day-old seedling leaves of some cotton cultivars grown under normal and water deficit conditions.

Varieties	Water condition	Cultivation	Wet weight, mg (%)	Dry weight, mg (%)	Water amount mg, (%)	Transpiration rate, mg H_2O/ g/hour	Water retention property, %/hour	Water potential, Bar
S-6524	NW	Control	347,9±16,4 100%	58,8±1,5 16,9%	289,1±7,9 83,1%	110,7±2,4	29,2	–12,1±0,5
		EM	349,4±15,3 100%	60,1±1,5 17,2%	289,3±8,2 82,8%	125,5±2,8	28,9	–12,3±0,5
		Difference	1,5	0,3%	0,3%	14,8	0,3	0,2
	WD	Control	268,8±12,6 100%	54,3±1,2 20,2%	214,5±7,2 79,8%	93,4±2,2	22,7	–19,4±0,8
		EM	305,3±14,1 100%	57,1±1,5 18,7%	248,2±7,5 81,3%	87,7±2,6	23,1	–20,9±0,9
		Difference	36,5	1,5%	1,5%	5,7	0,4	1,5
		Control	310,4±15,3 100%	53,7±1,2 17,3%	256,7±8,5 82,7%	101,8±2,7	29,7	–12,8 ±0,4

Khorezm-150	NW	EM	316,6±14,7 100%	55,4±1,1 17,5%	261,2±9,3 82,5%	106,6±2,5	29,5	−12,5±0,5
		Difference	6,2	0,2	0,2%	4,8	0,2	0,3
	WD	Control	243,4±11,6 100%	49,9±0,8 20,5%	193,5±5,7 79,5%	74,4±1,7	19,6	−20,4 ±0,8
		EM	284,6±13,5 100%	53,5±1,2 18,8%	231,1±8,4 81,2%	70,2±1,8	20,1	−21,9 ±0,8
		Difference	41,2	1,7%	1,7%	4,2	0,5	1,5
Namangan 77	NW	Control	288,8±13,7 100%	51,4±2,8 17,8%	237,4±7,6 82,2%	129,5±3,2	34,2	−13,7 ±0,5
		EM	300,5±14,6 100%	54,7±3,1 18,2%	245,8±9,4 81,8%	139,7±3,5	33,8	−13,1 ±0,5
		Difference	11,7	0,4%	0,3%	10,2	0,4	0,6
	WD	Control	195,2±9,1 100%	45,3±0,7 23,2%	149,9±7,9 76,8%	23,3±0,5	25,3	−16,7 ±0,7
		EM	257,5±12,7 100%	49,7±0,8 19,3%	207,8±9,9 80,7%	17,2±0,4	25,9	−18,6 ±0,8
		Difference	62,3	3,9%	3,9%	6,1	0,6	1,9
Farovon	NW	Control	321,4±12,3 100%	55,6±1,4 17,3%	265,8±10,6 82,7%	155,7±2,8	46,6	−12,0 ±0,5
		EM	327,5±11,4 100%	58,3±1,5 17,8%	269,2±10,3 82,2%	173,5±3,2	45,8	−11,5 ±0,4
		Difference	6,1	0,5%	0,5%	17,8	0,8	0,5
	WD	Control	173,0±8,8 100%	44,3±0,8 25,6%	128,7±6,8 76,4%	37,8±0,4	24,4	−15,3 ±0,6
		EM	244,8±10,4	49,7±1,1 20,3%	195,1±8,4 79,7%	25,7±0,3	24,8	−17,8 ±0,7
		Difference	71,8	5,1%	3,3%	12,1	0,4	2,5

Mean values ± mean standard deviation from seedling measurements are presented for each variety.

As shown in the table, seedling height decreases by 9.0-7.0% in drought-resistant S-6524 and Khorezm-150 varieties, and by 52.1-43.3% in drought-resistant Namangan 77 and Farovon varieties.

EMI treatment has been studied to increase seedling height in cotton cultivars. However, this increase is 7.7%-11.0% in the drought-resistant varieties S-6524, Khorezm-150, and 10.2-78.9% in the varieties with low resistance (Namangan-77 and Farovon). Compared to this, pre-planting EMI treatment is most effective on low drought tolerant cultivars, leading to increased resistance.

Under water deficit conditions, leaf water content, transpiration, water holding capacity, and water potential decrease (in absolute terms, water potential increases) in all cotton cultivars.

Then the water content in the leaves of the drought-resistant S-6524 and Khorezm-150 varieties decreases from 83.1-82.7% to 79.8-79.5% (≈3.3%), in the drought-resistant Namangan-77 and Farovon varieties it decreases from 82.2-82.7 to 76.4-76.8% (≈6.1%).

Transpiration of drought-tolerant varieties S-6524 and Khorezm-150 from 110.7 101.8 mg H_2O/gr/h to mg/ 93.4- 74.4mg H_2O/gr/h (by 15.6-27.0%), it decreases from 129.5-155.7 mg H_2O/gr/h to 23.3-37.8 mg H_2O/gr/h (by 82.0-75.7%) in the drought-resistant varieties Namangan-77 and Farovon.

Water retention capacity of drought-resistant S-6524 and Khorezm-150 varieties from 29.9%/h to 22.7-19.6%/h (by 22.3-32.9%), drought-resistant Namangan 77 and Farovon varieties decrease from 34.2-46.6% hours to 25.3-24.4% hours (26.0-47.6%).

In the drought-resistant S-6524 and Khorezm-150 varieties, the water potential is from 12.1 - 12.8 bar to 19.4-20.4 Bar (by 60%), in the drought-resistant Namangan 77 and Farovon varieties it decreases from 13.7 - 12.0 Bar to 16.7-15.3 bar (by 21.9-27.5%).

These data correspond to the data of scientific literature and can be explained by the increase in the amount of low-molecular osmoprotectors (proline, mono- and disaccharides) in drought-resistant cotton varieties under water deficit conditions.

EMI treatment of the studied cotton cultivars under standard conditions and water deficit did not affect the water content of the primary cotyledon leaves.

In the studied cultivars, transpiration increased in primary cotyledon leaves grown from EMI-treated seed under normal water conditions, which can be explained by the development of all processes under the influence of EMI. Under conditions of water deficit, transpiration decreases due to the increase in the concentration of osmolytes and the change in the activity of the osmotic apparatus in the studied varieties.

Leaf water holding capacity, i.e., the reduction in water content of seedlings grown from EMI-treated seed, does not change reliably within the wilting range.

The water potential of the primary seed leaves is almost the same (12.0-13.7bar) in standard water conditions in all investigated cultivars and varies within the margin of error when treated with EMF before sowing. This can be explained by the fact that the water potential is related to the soil water potential and the stability of the soil water potential under normal water conditions in laboratory conditions.

In the conditions of water shortage in the soil, the water potential of the leaves of primary seedlings grown from seedlings treated with EMI before sowing decreased (increased in absolute value), that is, in drought-resistant varieties (S- 6524 Khorezm-150) 1.5 bar ha., in drought-resistant varieties (Namangan 77, Farovon) 1.9-2.5 bar ha. This situation can be explained by the increased concentration of osmolytes in the leaves.

The amount of chlorophyll in the leaves of primary seedlings. In the development of plants, photosynthesis is defined as the main system and responds quickly to any environmental change. There is conflicting information in the literature about the effect of EMI on the photosynthetic system of plants.

For example, in the work of Turker M. et al. [6], growing maize and sunflower plants in a permanent magnetic field with a magnetic induction of 15 mTl showed that the concentration of chlorophyll increased in sunflower and decreased in maize.

In the works of Chvarkova E.A., Tupitsina L.S. [5], it was shown that the concentration of chlorophyll A and carotenoids in 5-day-old sprouts increased as a result of treatment with MAG-30 therapeutic apparatus (1-5mTl) for 30 minutes.

We also studied the effect of low-frequency pulsed EMI on the chlorophyll content of cotton seed leaves (Table 3).

Table 3. Amount of chlorophyll a and b in seed leaves of seedlings grown under normal and water deficit conditions (mg/g dry leaf basis)

Varieties	Water condition	Cultivation	Chlorophyll a mg/g %		Chlorophyll b mg/g %		Chl.a+Chl.b
S-6524	NW	Control	12,3±0,3	100%	4,3±0,1	100%	16,6±0,4
		EM	13,5±0,3		4,7±0,1		18,2±0,4
		Difference	1,2±0,6		0,4±0,2		1,6±0,8
	WD	Control	10,8±0,2	87,8%	3,8±0,1	88,4%	14,6±0,3
		EM	12,6±0,3		4,1±0,1		16,7±0,4
		Difference	**1,8**±0,5		0,3±0,2		**2,1**±0,7

Khorezm-150	NW	Control	13,4±0,3	100%	4,2±0,1	100%	17,6±0,4
		EM	15,1±0,4		4,6±0,1		19,7±0,5
		Difference	**1,5**±0,7		0,2±0,2		**2,1**±0,9
	WD	Control	11,7±0,3	87,3%	3,6±0,1	85,7	15,3±0,4
		EM	13,6±0,3		4,1±0,1		17,7±0,4
		Difference	**1,9**±0,6		0,5±0,2		**2,5**±0,8
Namangan-77	NW	Control	9,6±0,2	100%	3,3±0,1	100%	12,9±0,3
		EM	12,0±0,2		3,5 ±0,1		15,5±0,3
		Difference	**2,4**±0,4		0,2±0,2		**2,6**±0,6
	WD	Control	9,0±0,2	93,7%	3,0±0,1	90,9	12,0±0,3
		EM	10,8±0,2		3,4±0,1		14,2±0,3
		Difference	**1,8**±0,4		0,4±0,2		**2,2**±0,6
Farovon	NW	Control	9,8±0,2	100,0%	3,1±0,1	100%	12,9±0,3
		EM	11,6±0,2		3,3±0,1		14,9±0,3
		Difference	**1,8**±0,5		0,2±0,2		**2,0**±0,6
	WD	Control	9,1±0,2	92,8%	2,8±0,1	90,3	11,9±0,3
		EM	10,9±0,2		3,1±0,1		14,0±0,3
		Difference	**1,8**±0,4		0,3±0,2		**2,1**±0,6

As shown in the table, under conditions of water shortage, the amount of chlorophyll a and b decreased by 6.3-12% and 8.1-14.3%, respectively, these indicators correspond to the literature data [4].

Treatment of seeds with EMI resulted in increased chlorophyll content in seed leaves of the studied cultivars under both normal and water deficit conditions.

Therefore, treatment of cotton seed with EMI before planting increases the height of seedlings, dry and raw weight of seed leaves, decreases their transpiration processes under water shortage conditions, increases water holding capacity of leaves, increases water potential and chlorophyll content. All this increases the resistance to water deficit in the initial stages of plant development.

Conclusion. In laboratory experiments conducted on 15-day-old cotton seedlings under conditions of water deficit, a decrease in water content, transpiration rate, water holding capacity, water potential and chlorophyll content was observed in seed leaves. EMI treatment of cotton seed before planting further reduced water potential but increased chlorophyll content. This leads to increased resistance of plants to lack of water in the early stages of development.

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