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RESULTS OF THE PRE-SOWING ELECTROMAGNETIC TREATMENTS OF SEEDS FROM BULGARIAN PEPPER VARIETY

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Abstract: The study has established a continuing beneficial impact of electromagnetic treatments on seeds of Bulgarian peppers variety Kurtovska kapia 1 after 365 days storage to sowing at a voltage between the electrodes U=6 kV and duration of impact τ = 35 s. The germinating energy and laboratory germination increase compared to that of the control seeds of 4.6 to 5.2%.

Keywords: pre-sowing electromagnetic treatments, *Capsicum annuum* L., germination energy, laboratory seed germination.

INTRODUCTION

Seed aging is a genetically determined physiological process and is individual to each plant species and variety. Vaz et al. (2013), Rochalska et al. (2008); Martínez et al. (2014), etc. investigate the effects of seed aging of different crops by searching of alternative methods and technologies to stimulate sowing properties of the seeds. Studies on maize (Sirakov et al., 2015), wheat (Zahariev et al., 2013), cabbage (Antonova et al., 2013), potato (Sirakov, 2006), tomato (Sirakov et al., 2014), cotton (Stoilova et al., 2011), etc. have been carried out after electric pre-sowing treatment (electromagnetic and electrostatic) under laboratory conditions in Bulgaria. It has been established that pre-sowing electro-technological treatments can accelerate the emergence, development of plants and increase their yields. Ganeva et al. (2015) have studied the properties of seeds from recognized Bulgarian tomato varieties: Milyana, Plovdivska karotina, Vodoley F1, IZK Alya and Ideal, after 365 days stay of the seeds from pre-sowing electromagnetic treatment. It was found that with a voltage of U = 12 kV and a duration of impact τ = 35 s, and a one-year stay of the seeds until sowing, the germinated energy and the laboratory germination of the Milyana and Plovdivska karotina varieties increased averagely around 7%. Similar studies

were performed with beans „Obraztov Chiflik 12“, where it was found that at U1 = 5.5 kV and τ 1 = 5s an increase in root length by 6.25% and on sprouts by 43.06%, which was aided by the residual action of pre-sowing electromagnetic treatments (Sirakov, 2017). There are currently no studies available to monitor the effects of pre-sowing electromagnetic treatments on pepper seeds (*Capsicum annuum* L.).

The purpose of the study is to determine the effect of pre-sowing electromagnetic treatments on the storage life 365 days after the seeds treatment on the sowing and morphological properties of the seeds from Bulgarian pepper variety Kurtovska kapia 1.

MATERIALS AND METHODS

The experimental work was performed during the period 2016-2018 at the Maritsa Vegetable Crops Research Institute, Plovdiv, Bulgaria. The subject of the study was the sowing properties and morphological characters of three Bulgarian of pepper varieties – kapia type – Kurtovska kapia 1, intended for mid-early field production. The research was carried out jointly with the Department of Power Supply and Electrical Equipment of the Ruse University, Ruse. An electromagnetic field of alternating corona discharge between the blade-plane electrodes was used for pre-sowing seed treatment of the three pepper varieties. The controllable factors of influence are: the voltage U (kV) between the treatment electrodes, the duration of the impact τ (s), and the time of the seeds stay after treatment until sowing T (days). The experiment included 15 treatments in which the control factors varied at 3 levels (Table 1), i.e. a complete factor experiment of B^3 type was conducted (Mitkov and Kardashevski, 1977).

Table 1. Matrix of planning experiment

Treatments	Controllable factors					
	Voltage		Duration of impact		Length of stay	
	U		τ		T	
	level	kV	level	s	level	day
1	+	14	+	35	+	12
2	-	6	+	35	+	12
3	+	14	-	5	+	12
4	-	6	-	5	+	12
5	+	14	+	35	-	4
6	-	6	+	35	-	4
7	+	14	-	5	-	4
8	-	6	-	5	-	4
9	+	14	0	20	0	8
10	-	6	0	20	0	8
11	0	10	+	35	0	8
12	0	10	-	5	0	8
13	0	10	0	20	+	12
14	0	10	0	20	-	4
15	0	10	0	20	0	8

Fifteen treatments of processing in 3 replications were set in Petri dishes (100 seeds/replication) in laboratory conditions. The seeds were placed in a thermostat at 25°C and 95% humidity of the medium. The control is untreated seeds from the three varieties. Ten germinated seeds that have been randomized taken from each replication of the treatment were analyzed.

The following seed characteristics were studied: germinating energy – G.E. (%) and germination – G. (%), and the morphological features: root length ℓ_r (mm), hypocotyl ℓ_h (mm) and cotyledon ℓ_c (mm).

The indicators were recorded on the 6th and 14th day according to the ISTA methodology (2004), with the measurement performed with a caliper-gauge (up to 0.01 mm accuracy). The results were statistically processed by analysis of variance (Duncan, 1955; Lidanski, 1988) and they are expressed as a percentage of the control (% / K).

RESULTS AND DISCUSSION

Table 2 gives the results from a study of germination energy and laboratory germination of seeds treated in an electromagnetic field according to the variants of Table 1. The seeds have stayed 365 days until their sowing and the values are average for the study period. The results are given in % towards the control (% / K). The analysis shows that for the Kurtovska kapia 1 variety, a dominant positive effect on G.E. is observed after seed processing in treatment 9 (U = 14 kV, τ = 20 s, T = 8 days). This effect persisted for one year after the electromagnetic treatment, with the stimulation effect reaching 93.5%/K. This is significantly more from the observed treatments by a stay in the group of T = 8 days. An increase of the parameter in variant 4 with a voltage between the electrodes U = 6 kV and a duration of impact, τ = 5 s, T = 12 days by 76.9%/K was recorded.

Table 2. Results from the pre-sowing electromagnetic treatment on the sowing properties of the seeds

Length of stay, day	Treatments	Germination energy, %			Germination, %		
		$\bar{x} \pm$ sd	VC%	%/K	$\bar{x} \pm$ sd	VC%	%/K
K		18,00±6,38 cd	35,5	100,0	73,50 ±3,12ab	4,3	100,0
4	5	16,83±8,98 cde	53,3	93,5	61,00 ±6,95 de	11,4	83,0
	6	5,00±0,50 e	10,0	27,8	53,17 ±7,23 cde	13,6	72,3
	7	8,67±1,53 cde	17,6	48,2	62,67 ±6,64 e	10,6	85,3
	8	4,67±2,36 e	50,6	25,9	57,00 ±5,57 de	9,8	77,6
	14	5,17 ±1,61 de	31,1	28,7	38,33 ±5,11 f	13,3	52,2
8	9	34,83±12,29 a	35,3	193,5	75,33 ±6,82 ab	9,1	102,5
	10	16,00±4,27 cde	26,7	88,9	62,67 ±8,69 cde	13,9	85,3
	11	9,83±1,76 cde	17,9	54,6	72,83 ±0,76 abc	1,1	99,1
	12	21±1,80 bc	8,6	116,7	67,33 ±4,80 a-d	7,1	91,6
	15	9,33±1,61 cde	17,2	51,9	59,06 ±2,77 de	4,7	80,4
12	1	16,83±6,93 cde	41,2	93,5	74,83 ±6,26 ab	8,7	101,8
	2	18,83±3,82 c	20,3	104,6	77,33 ±0,76 a	1.0	105,2
	3	19,17±3,18 c	16,6	106,5	74,67 ±6,66 ab	8,9	101,6
	4	31,83±17,86 ab	56,1	176,9	72,50 ±5,57 de	7,7	98,6
	13	11,83±2,93 cde	24,8	65,7	64,83 ±3,33 bcd	5,1	88,2

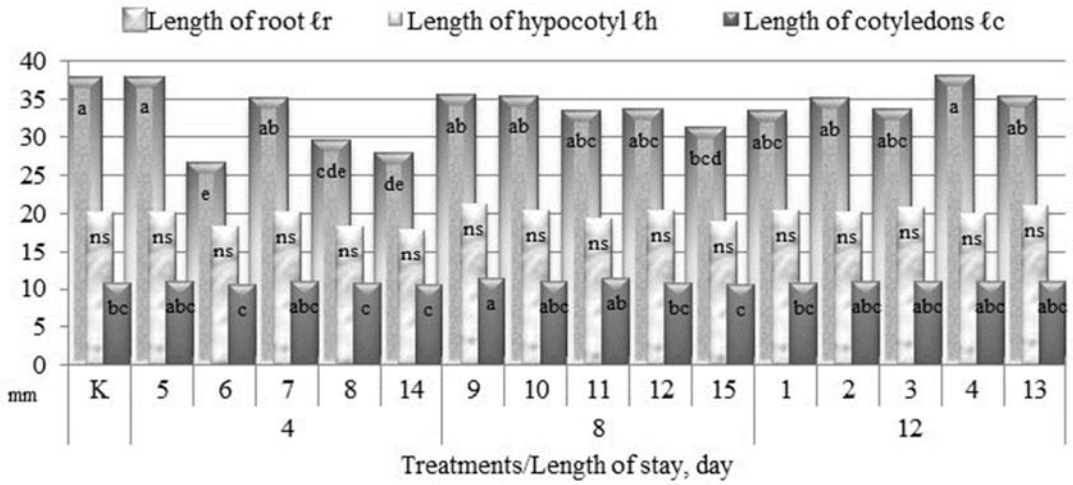
a,b,c... – Duncan's Multiply Range Test, P<0.05, ns – non significant

The results demonstrated that after treatment of the seeds with the parameters of the other variants, suppression of the germinating energy is obtained, which is in deferent degrees for the different variants of processing and for the different days of stay of the seeds. A negative effect was observed in all treatments at T = 4 days, where the germination energy decreased to 44.8%, averagely for the group, compared to the control.

The results of the influence of the controllable factors on the root length ℓ_r, hypocotyls length ℓ_h and cotyledons length ℓ_c are shown in Figure 1. The average values of the observed control parameters are ℓ_r – 37.02 mm, ℓ_h – 20.25 mm, ℓ_c – 10.84 mm.

The analysis of the data shows that treatment 9 with U = 14 kV, time τ = 20 s and a stay of the seeds T = 8 days is dominant with the values of the observed parameters. As a percentage of the control, the length of the hypocotyl is ℓ_h = 5.2%/K, the length of the cotyledon is ℓ_c = 4.9%/K, while the root length shows a suppressive effect ℓ_r = 7.1%/K.

The data show that after one year of stay of the seeds before sowing, the root development of the sprouted plants is shorter than that of the control and only in treatments 4 and 5 with U = 14 kV and U = 6 kV, time τ = 35 s and a stay of T = 12 and 4 days the minimal beneficial effect of pre-sowing electromagnetic treatments remains. The situation is similar for the length of the hypocotyl ℓ_h, after the analysis, the effect of stay after the electromagnetic processing does not have a significant positive effect on the seeds. In treatment 9 with U = 14 kV, time τ = 20 s and a stay of T = 8 days, a slight stimulating effect of 5.2%/K was established, but the data are not statistically significant.



a, b, c… – Duncan's Multiply Range Test, P<0.05, ns – non significant

Figure 1. Morphological characteristics of the seeds of Kurtovska kapia 1 variety

In the character cotyledon length – ℓ_c was established that the long stay of the seeds after the electromagnetic treatments does not make any significant changes in the data compared to the control. In this case the pre-sowing effects with longer stay of the seeds to the sowing have kept a positive influence on cotyledon growth in some treatments. The most remarkable treatment is 9 with U = 14 kV, time τ = 20 s and a stay of T = 8 days with 4.9%/K. The comparison of the lengths of cotyledons processed at different days of stay after 8 days keeps the tendency for stimulating electromagnetic processing. The increase is averagely 1.4% compared to the untreated control.

The results obtained show that there are residual effects of the pre-sowing electromagnetic treatments, but they are different for different cops. This could be explained by the difference in the U values used between electrodes and duration of seed treatment (Zahariev et al. 2013; Sirakov et al. 2014; Palov et al. 2012; Stoilova et al. 2012).

Data from the studied sowing properties for the variety were analyzed by three-way analysis of variance (Table 3). The evaluation of the interaction of factors – duration of impact (A), voltage (B) and downtime before sowing (365 days) (C) was performed by this analysis. Statistical differences for germination energy are proven between processing time, voltage and downtime until sowing, as well as the interaction between all according to the three-factor analysis of variance.

Table 3. Three-way analysis of variance

Factors of variation	Degree of freedom	Germination energy, %		Germination, %	
		Mean square	Influence	Mean square	Influence
	df	MS	%	MS	%
Duration of impact A	2	661,79**	4,82	1831,51***	8,42
Voltage B	5	312,22***	5,68	586,10***	6,74
Downtime before sowing C	2	4186,13***	30,48	9031,56***	41,54
Interaction A x B	10	182,49**	6,64	234,84**	5,40
Interaction A x C	4	399,26***	5,81	760,63***	7,00
Interaction B x C	10	478,98***	17,44	178,61*	4,11
Interaction A x B x C	20	102,58*	7,47	188,62**	8,68
Residual	108	55,04		72,90	

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

The greatest influence on the germination energy showed the effect (30.48%), followed by the interaction B x C (17.44%) and the interaction between the three factors A x B x C (7.47%), while the lowest effect was recorded for the treatment duration A (4.82%) and voltage B (5.68%), i.e. the seeds react differently to electromagnetic treatments at set values of the controllable factors.

The results of the analysis of variance demonstrate that all three factors are significant for the germination. The strongest source of variation was the stay before sowing (41.54%), followed by the interaction between the three factors (8.68%).there are proven statistical differences in other factors and interactions between them.

The general analysis of the data in Table 3 show that there is a peculiarity in controllable factors of impact in post effect from the seed stay on the studied characters. The three-factor analysis of variance in the germinating energy and germination characters proves the beneficial effect of the residual effect of the treatments as a determining factor in the pre-sowing electromagnetic treatment in the corona discharge field of the seeds of the studied pepper variety.

CONCLUSIONS

As the age of the seeds increases, the laboratory germination gradually decreases, which is also a specific feature in vegetable seeds. Data of the analysis demonstrate that there is a positive effect on germination for pepper variety Kurtovska Kapia 1 in treatments 9 (U = 14 kV, τ = 20 s, T = 8 days), 1, 2 and 3 (U = 6 and 14 kV, τ = 5 and 35 s at T = 12 days).This effect was maintained 365 days after the electromagnetic processing as for treatment 9 - 2.5%/K, for treatment 1- 1.8%/K, for treatment 2 - 5.2%/K and treatment 3 - 1, 6%/K.

It was established that after a stay of the seeds for a year a strong suppressing effect on germination is observed in all treatments in stay of 4 days. This effect is the most significant in variant 14 (U = 10 kV, τ = 20 s), where the decrease is by 47.8% towards the control plants.

REFERENCES

1. Antonova G., M. Mihov, K Sirakov, S. Zakhariev, I. Palov. (2013). Study of the effect of pre-sowing electromagnetic treatment on germination of seed of cabbage. *Agricultural Engineering*, Bulgaria, 1, 22-26. (Bg).

2. Duncan, D. (1955). Multiple ranges and multiple F-test. Biometrics 11: 1-42.

3. Ganeva, D., Sirakov, K., Mihov, M., Zahariev, S. and Palov, I. (2015). Influence of pre-sowing electromagnetic treatments and duration of storage on germination energy and laboratory germination of seeds from Bulgarian tomato varieties. *INMATEH-Agricultural Engineering*, 45(1).

4. ISTA. (2004). International Seed Testing Association: International rules for seed testing. Bassersdorf, Switzerland.

5. Lidanski, T. (1988). Statistical methods in biology and agriculture. Zemizdat, Sofia, 375 pp. (Bg)

6. Martínez, F. R., Pacheco, A. D., Aguilar, C. H., Pardo, G. P., and Ortiz, E. M. (2014). Effects of magnetic field irradiation on broccoli seed with accelerated aging. *Acta Agrophysica*, 21(1).

7. Mitkov, A and Kardashevski S. (1977). Statistical methods in agricultural machinery. Zemizdat, Sofia, 501 pp. (Bg).

8. Palov Iv., K. Sirakov, A. Stoilova and Radevska M. (2012), Impact of electromagnetic treatment and storage term on the pre-sowing properties of cotton seeds. II. Lentgh of primary root system – root and germ. *Bulgarian Journal of Crop Science*, 49, 1, 28-36.

9. Rochalska M., Grabowska K., Ziarnik A. (2008). Impact of low frequency magnetic fields on yield and quality of sugar beet. *International Agrophysics*, 23, 163-174.

10. Sirakov K. (2006). Analysis of results after pre-transplant electromagnetic treatment of potato tubers. *Agricultural Engineering*, Bulgaria, 1, 18-23. (Bg)

11. Sirakov K., Ganeva D., Mihov M., Zahariev, S., Palov I. (2014). Investigation of the effect of pre-sowing electromagnetic processing and shelf life on the sowing qualities of seeds of the Miliana tomato variety. *Agricultural Engineering, Bulgaria*, 3-4, 16-24. (Bg)

12. Sirakov K., Mihailov L., Zahariev Sv., Palov I. (2015). Results of laboratory tests of the interaction between the type of storage vessel and the pre-sowing electromagnetic treatment of seeds of the French maize hybrid LG34.75. In: *Proceedings of University of Ruse “Angel Kanchev”*, v.54, b.3.1., 222-228. ISBN 1311-3321. (Bg)

13. Sirakov K. (2017).Study of the residual effect of the pre-sowing electromagnetic treatment on seeds of beans stored in conditions of natural aging. In: *Proceedings of University of Ruse “Angel Kanchev”*, v.56, b.3.1, Ruse, 2017, ISBN 1311-3321.

14. Stoilova A., Palov I., Sirakov K., Radevska M. (2011). The results of a study of the influence of pre-sowing electromagnetic treatment of seeds of Bulgarian cotton varieties // IN: *Ecology, Genetics, Selection in the Service of Humanity, International Scientific Conference, Research Institute of Agricultural Sciences*, Ulyanovsk, Russia, 442-452. (Ru)

15. Stoilova, A., M. Radevska, K. Sirakov, Palov Iv. (2012). Impact of electromagnetic treatment and storage term on the pre-sowing properties of cotton seeds. I. III. Mass of primary root system – root and germ. *Bulgarian Journal of Crop Science*, 49, 1, 37-45.

16. Todorova, V. (2011). Kurtovska kapia 1 – new Bulgarian pepper cultivar. In*: Proceedings of the XIV International Scientific Practical Conference "Agrarian Science - Agricultural Production in Siberia, Mongolia, Kazakhstan and Bulgaria"*. Krasnoyarsk, 1. 15-18.

17. Vaz M.V.H., Moure C.S., Dourado-N.D., Lourenço P.T., Neves D.M.A. (2013). Seed vigor and initial growth of corn crop*. Journal of Seed Science*, 35, 64-69.

18. Zahariev, Sv., Sirakov K., Kostov K. & Palov I. (2013). Laboratory results of residual and cumulative effects of pre-sowing electromagnetic treatments on wheat seeds. In: *Proceedings of University of Ruse “Angel Kanchev”*, v. 52, b.3.1. (Bg)