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STUDY OF THE INFLUENCE OF PRE-SOWING ELECTROMAGNETIC TREATMENTS ON THE PROPAGATING QUALITIES OF BEAN SEEDS AFTER NATURAL AGING

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Abstract

Research has been carried out on seeds of the Bulgarian variety "Obraztsov Chiflik 12". The seeds are divided into two groups. They are stored in conditions of natural aging. The first group of seeds remained for 5 years, and the second group for 6 years until the date of the study. It was found that the pre-sowing electromagnetic treatment stimulated the laboratory germination, the lengths of the sprouts and the accumulated dry mass of the plants, which sprouted from the seeds that remained for 6 years. After a stay of the seeds for 5 years and performed pre-sowing electromagnetic treatment, an increase in the lengths of the roots and sprouts was achieved, respectively to 121.20% and 135.43% compared to the remaining untreated seeds. The regime parameters of the pre-sowing electromagnetic treatments, which stimulate the sowing qualities of old seeds, have been established. The results of the research show that the pre-sowing electromagnetic treatments have a stimulating effect on the sowing qualities of bean seeds, which have been stored for a long period.

***Key words**: bean seeds, pre-sowing electromagnetic treatments, electromagnetic field effect.*

INTRODUCTION

Among the legumes grown in Bulgaria, beans are of the highest economic significance. This is essentially due to the high nutritional value of the seeds used as protein food. The amount of protein contained in beans varies from 20% to 30%, depending on the variety and the conditions of growing. Beans are a major plant source of protein in human nutritional balance. In addition to proteins, beans contain carbohydrates - 62%, small amounts of fatty acids - about 1.8%, and mineral salts - 9.9% in average. Nowadays, different cultivation approaches are applied to increase the yields of agricultural crops. Such methods are fertilization with mineral and foliar fertilizers (Dobreva et al., 2018), intensive irrigation (Saldzhiev et al., 2014), rotation of crops, etc.

In terms of crop rotation, the use of legumes is increasingly brought into focus. Beans are a good forerunner of almost any agricultural crop. They are a particularly appropriate forerunner of cereal grains. This is due to the fact that beans are a source of biological nitrogen readily available to plants. Under the conditions of increasing rates of nitrogen fertilization of the soil, legumes have an important and mandatory role for increasing yields in the system of organic farming (Saldzhiev & Muhova, 2013).

For a number of reasons, including the ongoing climate change, it is not always possible to provide quality seeds for the next production year. In such cases it becomes necessary to use old seeds, i.e. ones that are stored under the conditions of natural aging. Such seeds have reduced biological properties, and need activation.

The rate of natural aging of seeds is determined by genetics and is phenotypically plastic, i.e. it reflects the specificity of the species, variety and production conditions (Реймерс, 1979; Фурса, 1974).

It has been established (Powell & Mattewa, 1984) that the mechanism and the biochemical nature of the aging processes of seeds, stored under normal or extreme conditions, are unidirectional.

A number of studies have shown that seeds can be stimulated in different ways before sowing. This helps to improve the qualitative composition of the seeds, which is a prerequisite for higher yields.

In Spain, for example, (Flórez et al., 2014) and (Martinez et al., 2017) conducted studies on the pre-sowing magnetic treatment of triticale seeds. In Bulgaria, on the other hand, the effect of electromagnetic pre-sowing treatments of triticale seeds (Muhova et al., 2016) on certain laboratory parameters and on the germination energy and laboratory germination capacity (Sirakov, 2006; Sirakov et al., 2016) was studied. Studies in both countries have shown the positive effects of magnetic and electro-magnetic treatment of the seeds on plant development. Similar results for the lengths and number of roots and lengths of sprouts have been found for the electromagnetic treatment of triticale seeds of the variety Kolorit (Sirakov et al., 2019).

It is a known fact that certain changes take place in the seeds during and after the pre-sowing electromagnetic treatments, which can intensify the processes of growth and fruit-bearing of the plants. Generally speaking, pre-sowing electro-magnetic treatments with appropriate values of the control factors stimulate plant development.

The aim of this study is to determine the effect of pre-sowing electromagnetic treatments on the sowing qualities of bean seeds stored for several years after their production.

MATERIALS AND METHODS

For the purposes of this study, seeds of field beans of the Bulgarian variety "Obraztsov chiflik 12" (Добрев & Патенова, 2003), were used. During the study, the seeds were divided into three groups (**A**, **M** and **L**) and left to age naturally in storage. The seeds from group **A** were produced in the year preceding the study and therefore remained stored for 1 year. The seeds from group **M** were stored for 5 years, and those from group **L** – for 6 years.

The seeds from group **A** were used as controls. They did not undergo electromagnetic treatment. The seeds from groups **M** and **L** were subjected to three-stage electromagnetic treatment, as per invention patent No. 42681 (Палов et al., 1998). The voltage U, kV between the electrodes, and the duration of the electromagnetic treatment τ, s., were taken to be the controlled factors.

The electromagnetic treatment of the seeds from groups **M** and **L** was carried out with such values of the controlled factors (Table 1) that had produced positive results in prior studies (Палов et al., 2012; Патенова et al., 2009; Palov & Sirakov, 2004).

The results of the pre-sowing electromagnetic treatment of the bean seeds in the groups **M** and **L** were compared with the results obtained from the seeds in the control group – **A**.

After the pre-sowing electromagnetic treatment, the seeds remained stored for further 14 days (Палов et al., 2009; Палов et al., 2012; Патенова et al., 2009) and then put to germinate by the standard methodology (using a thermostat).

Tests were performed on the laboratory parameters lengths of roots ℓ_{root} and lengths of sprouts ℓ_{spr}, and the indicator germination capacity.

Table 1. Values of controlled factors in the pre-sowing electromagnetic treatment of bean seeds of the variety "Obraztsov chiflik 12", groups **M** and **L**

For seeds from group L						
Variant	U_1, kV	τ_1, s	U_2, kV	τ_2, s	U_3, kV	τ_3, s
1	4	5	2,5	15	2	25
2	5,5	5	4	15	3,6	25
3	5,5	5	4	15	5,5	25
4	Control, untreated seeds from group **L** – C_L					
For seeds from group M						
5	5,5	5	4	15	3,6	25
6	Control, untreated seeds from group **M** - C_M					
7	Control, untreated seeds from group **A** - C_A					

Measurements were taken, following which the germinated seeds were left to dry naturally under laboratory conditions until there was no further change in their dry mass. At that point, the dry mass $\mathbf{m}_{dry}$ of the plants was measured for the specified test variants.

All data from the measurements and tests were given as a percentage of the control – untreated

seeds from the respective group, for example the control seeds from group **L** are coded as C_L, and those from group **M** as C_M.
To determine how the duration of storage affected the seeds, tests were also made on the untreated control seeds from group **A** (1-year old), coded as C_A.

RESULTS OF THE TESTS

Table 2 shows the results of the laboratory tests of the average lengths of the roots ℓ_{root} and sprouts ℓ_{spr} and the dry mass m_{dry} of the control seeds from the groups **A** and **L**.

Table 2. Laboratory test results of control (untreated) bean seeds "Obraztsov Chiflik 12" from the groups **A** and **L**.

Observed parameter	Seeds from group:	
	L	A
Germination capacity, %	70,0	92,5
$\overline{\ell}_{root}$, mm	76,5	113,5
$\overline{\ell}_{spr}$, mm	51,4	71,5
m_{dry}, g	38,1	46,7

It can be concluded that the extended 6-year period of storage of the seeds from group **L** has had a suppressive effect on all observed indicators of the control seeds (Table 2).
The extended period of storage – 6 years – resulted in lower germination capacity of the seeds in group **L**. At the time of testing, their germination capacity under laboratory conditions was 70%, and for the 1-year old seeds from group **A** it was 92,5%. The determined average lengths of the roots and sprouts in the control seeds from group **L** were $\overline{\ell}_{root\,L}$ =76,5mm and $\overline{\ell}_{spr\,L}$=51,4mm, respectively. They were considerably shorter from the corresponding lengths measured in the seeds of the same variety from group **A**, in particular: $\overline{\ell}_{root\,A}$=113,5mm and $\overline{\ell}_{spr\,A}$=71,5mm. Also lower was the dry mass m_{dry} of the sprouted seeds from group **L**, its value was m_{dryL}=38,1g. It measured 81,6% of the dry mass of the seeds from group **A**, which was m_{dryA}=46,7g.
The results of the observed average values of the lengths of roots $\overline{\ell}_{root}$ and sprouts $\overline{\ell}_{spr}$, the dry mass m_{dry} of the plants, and the laboratory germination capacity of the control seeds from group **L** expressed as a percentage of the controls from group **A**, i.e. $C_{L/A}$ are shown in (Figure 1).

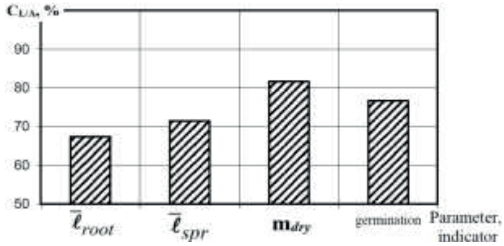

Figure 1. Test results of the control bean seeds from group **L**, expressed as a percentage of the corresponding ones from group **A**

The extended 6-year period of storage affected adversely the observed parameters $\overline{\ell}_{root}$ and $\overline{\ell}_{spr}$ of the control seeds C_L from group **L**.
To compare the control seeds C_L and the corresponding control seeds C_A from group **A,** the following average values for the lengths of roots and sprouts were measured: $\overline{\ell}_{root\,L}$= 67,4%/$C_A$ and $\overline{\ell}_{spr\,L}$= 71,5%/C_A.
The foregoing results lead to the conclusion that seeds "age", which affects their vital indicators. Thus, the germination capacity of the seeds from group **L** (6-year old) also dropped to just 76,7%/C_A by comparison to the germination capacity of the beans from group **A**.
The impaired vitality of the seeds from group **L** resulted in the accumulation of less dry mass during their sprouting under laboratory conditions, m_{dryL} = 81,7%/C_A.
Table 3 shows the test results for the germination capacity, lengths of roots and sprouts, and accumulated dry mass of the germinated seeds after their treatment by variants 1…3 (Table 1). All collected data are given as a percentage of the corresponding control seeds from group **L** (C_L) and the control seeds from group **A** (C_A).
It can be established from Table 3 that the pre-sowing electromagnetic treatment of the seeds by variants 1 and 2 (Table 1) helped to increase their laboratory germination capacity to 103,6%/C_C and 110,7%/C_L. respectively. Therefore, the germination capacity of the

control seeds from group **L** was 70,0%, while for the seeds treated by variants 1 and 2 it was higher: 72,5% and 77,5%, respectively.

Table 3. Laboratory test results obtained after the pre-sowing electromagnetic treatment of bean seeds "Obraztsov chiflik 12" from group **L** (stored for 6 years)

Observed parameter and indicator	Treatment variants		
	1	2	3
Germination capacity, %	72,5	77,5	50,0
%/C_L	103,6	110,7	71,4
%/C_A	78,3	83,8	54,1
$\overline{\ell}_{root}$, mm	60,3	51,5	52,6
%/C_L	78,9	67,4	68,8
%/C_A	53,1	45,4	60,6
$\overline{\ell}_{spr}$, mm	52,8	52,6	55,2
%/C_L	102,8	102,3	107,3
%/C_A	73,9	73,5	77,2
$\mathbf{m}_{dry}$, g	36,0	39,7	25,7
%/C_L	94,6	104,3	67,3
%/C_A	77,3	85,2	55,0

However, the pre-sowing electromagnetic treatment did not mitigate the biological aging of the seeds over the 6-year long period of storage. In comparison with the control seeds from group **A**, which remained in storage for 1 year only, the laboratory germination capacity for the older seeds from group **L** was 78,3%/C_A for variant 1, 83,8%/C_A for variant 2 and 54,1% C_A for variant 3.

The discussed pre-sowing treatment had a suppressive effect on the development of the roots and their lengths were smaller compared to those of the controls C_L.

As with germination capacity, the pre-sowing treatment stimulated the growth of the sprouted seeds from group **L**; for variants 1 and 2, the lengths of the sprouts were above 102%/C_L.

Compared with the lengths of the sprouts of the controls from group **A**, the sprouts of the plants in group **L** were shorter in length, whereby the length for variant 1 was 73,9%/C_A, for variant 2 - 73,5%/C_A, and for variant 3 - 77,2%/C_A.

The analysis of the data on the accumulated dry mass $\mathbf{m}_{dry}$ of the sprouted plants shows that it increased to 104.3% / C_L due the treatment by variant 2. In this variant, the highest value of dry mass, as compared to that of the seeds produced and stored for 1 year, was achieved - 85.2% / C_A.

The received results and the performed analysis lead to the conclusion that the pre-sowing electromagnetic treatment of the seeds from group **L** by variant 2 (Table 1) helped to improve the germination capacity and increase the lengths of sprouts and the accumulated dry mass.

According to Table 1, variants 5 and 6 were applied to test bean seeds of the variety "Obraztsov chiflik 12", stored for 5 years – group **M**. The seeds from group **M** were subjected to electromagnetic treatment by variant 5, using the parameters of variant 2 (group **L)** for which the best results had been obtained. The seeds from variant 6 were left untreated and were used as controls for the respective group – C_M.

The results of the observed average lengths of the roots $\overline{\ell}_{root}$ and sprouts $\overline{\ell}_{spr}$, the dry mass $\mathbf{m}_{dry}$ of the plants and the laboratory germination capacity of the control seeds from group **M,** expressed as a percentage of the controls from group **A,** are shown in (Figure 2).

It can be concluded from Figure 2 that the shorter period of storage of the seeds, reduced from 6 to 5 years, had a less suppressive effect on the lengths of the sprouts. The sprouts of the control seeds of group **L** (stored for 6 years) had lengths of $\overline{\ell}_{spr\,L}$=71,5%/C_A, which were smaller than the ones of the controls from group **M** (stored for 5 years) $\overline{\ell}_{spr\,M}$ =92,5%/C_A.

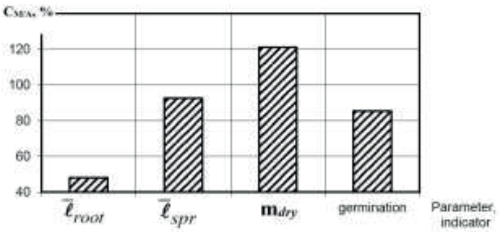

Figure 2. Test results of control bean seeds from group **M**, expressed as a percentage of the corresponding ones from group **A**

The fact that the roots of the sprouts in group M $\overline{\ell}_{root\,M}$ =48,1%/C_A were of smaller lengths could be deemed compensated by the larger quantity of accumulated mass $\mathbf{m}_{dryL}$= 120,9%/C_A. Its value is greater when compared with the dry mass of the control seeds from group **L** ($\mathbf{m}_{dryL}$= 81,7%/C_A – (Figure 1.).

In comparison with the seeds having remained in storage for 6 years, those stored for 5 years had a higher germination capacity - for the seeds from group **L** it was 76.7%/ C_A, and for the seeds from group **M** - 86.4% / C_A.

The results of the treatments of the seeds from group M are shown in (Table 4).

Table 4. Laboratory test results after pre-sowing electromagnetic treatment of bean seeds “Obraztsov chiflik12” from group **M** (stored for 5 years)

Treatment variant 5 (Table 1)					
$\overline{\ell}_{root\,M}$, mm			$\overline{\ell}_{spr\,M}$, mm		
mm	%/C_M	%/C_A	mm	%/C_M	%/C_A
66,1	121,2	58,3	89,6	153,4	125,3

Based on the performed laboratory studies is was found that the electromagnetic treatment had a beneficial effect on the lengths of the grown roots and sprouts. With the control variant 6 for group **M**, the length of the roots was 54,6mm, and the length of the sprouts 66,1mm. The roots and sprouts that grew from the seeds subjected to electromagnetic treatment, had higher values of the average length $\overline{\ell}_{root\,M}$ =66,1mm, and $\overline{\ell}_{spr\,M}$ =89,6mm. These data, expressed as a percentage of the controls from group **M,** are $\overline{\ell}_{root\,M}$ =121,2%/C_M and $\overline{\ell}_{spr\,M}$ = 135,4%/C_M, respectively,

It can be concluded from Table 4 that the pre-sowing electromagnetic treatment of the seeds from group **M** had a positive effect also on the lengths of roots. By comparison with the lengths of roots of the controls from group **A**, there was an increase to $\overline{\ell}_{root\,M}$ = 58,3%/C_A. It was found that the pre-sowing treatment had a stronger stimulating effect on the growth of the sprouts. Compared to the controls from group **A**, their length was $\overline{\ell}_{spr\,M}$ =125,3%/C_A. The parameters of the electromagnetic treatment were the ones given for variant 5 in (Table 1).

The analysis of the data contained in Table 3 and Table 4 confirm the existence of a pattern - the pre-sowing electromagnetic treatments have a stronger stimulating effect on the growth of the sprouts of bean seeds rather than of their roots.

CONCLUSIONS

1. It was found that the extended storage period of 6 years had an adverse effect on the observed parameters and indicators of the control (untreated) seeds from group **L**. Compared to the control seeds from group **A** (C_A), the average lengths of the roots and sprouts were, respectively, $\overline{\ell}_{root\,L}$= 67,4%/$C_A$ and $\overline{\ell}_{spr\,L}$= 71.5%/C_A, the germination capacity was 76.7% / C_A, and the accumulated dry mass $\mathbf{m}_{dryL}$ = 81,7%/C_A.

2. It was found that the performed pre-sowing electromagnetic treatment of seeds from group L (having remained 6 years in storage) by variants 1 and 2 (table 1):

a) helped to increase the laboratory germination capacity to 103,6%/C_L and 110,7 %/C_L, respectively.

b) the pre-sowing electromagnetic treatment stimulated the growth of the sprouts of the seeds from group **L,** with length of the sprouts exceeding 102%/C_L for variants 1 and 2.

c) it can be seen by the accumulated dry mass $\mathbf{m}_{dry}$ of the sprouted plants that the treatment by variant 2 contributed for its increase to 104,3%/C_L. In this variant, the highest value of dry mass (compared with that of the control group **A**) was obtained - 85,2%/C_A.

3. The pre-sowing electromagnetic treatments did not compensate for the biological ageing of the seeds over their extended 6-year period (**L**) of storage:

a) in comparison to the control seeds from group **A,** the old seeds (group **L**) showed lower laboratory germination capacity: for variant 1 it was 78,3%/C_A, for variant 2 – 83,8%/C_A and for variant 3 – 54,1%/ C_A.

b) compared with the lengths of sprouts of the seeds from group A, the sprouts grown from the seeds in group **L** were of smaller length: for variant 1 it was 74,0%/C_A, for variant 2 - 73,5%/C_A, and for variant 3 - 77,2%/C_A.

4. The shorter period of 5 instead of 6 years of storage of the seeds in group **M**, in combination with the applied pre-sowing electromagnetic treatment, helped to:

a) increase the lengths: of the growing roots to $\overline{\ell}_{root\,M}$= 121,2%/$C_M$ and of the sprouts to $\overline{\ell}_{spr\,M}$= 135,4%/C_M as compared to the controls - **M**.

б) better stimulate the growth of the sprouts. Compared with the controls from group **A**, their length is equal to $\overline{\ell}_{spr\,M}$ = 125,3%/C_A.

5. The test results show that the pre-sowing electromagnetic treatments have a stimulating effect on the sowing qualities of bean seeds that have been stored for an extended period after their production.

REFERENCES

Dobreva, S., Kirchev, H., & Muhova, A. (2018). Grain yield of triticale varieties depending on the foliar fertilization in the conditions of increasing norms of fertilization of the soil with nitrogen. *Research Journal of Agricultural Science*, *50*(4), 122–126.

Flórez, M., Martínez, E., Carbonell, M.V., Álvarez, J., Campos, A. (2014). Germination and initial growth of triticale seeds under stationary magnetic treatment. *Journal of Advances in Agriculture*, *2*(2)., 72–79.

Martinez, E., Florez, M., Carbonell, M.V. (2017). Stimulatory Effect of the Magnetic. Treatment on the Germination of Cereal Seeds. *International Journal of Environment, Agriculture and Biotechnology (IJEAB), 2*(1), 375–381.

Muhova, A., Sirakov, K., Stoilova, A., Stefanova-Dobreva, St., Palov, Iv. (2016). Study the effects of pre-sowing electromagnetic treatment of some laboratory parameters on triticale seeds. *International Scientific and Practical Conference "WORLD SCIENCE", Proceedings of the III International Scientific and Practical Conference "Topical Problems of Modern Science and Possible Solutions"*, *6*(10-14), Dubai, UAE, 40–45.

Saldzhiev I., Muhova A., (2013). Rezults on yields of sunflower cultivated under conventional and biological methods. *Science & Technologies*, *III*(6), Plant studies, 86–90.

Saldzhiev, I., Muhova, A., Dobreva, S., (2014). Productivity and economic effect for cotton cultivated under different inter - row space and irrigation rate. *Turkish Journal of Agricultural and Natural Sciences*, Special Issue: 1, 1000–1004.

Sirakov, K., Stoilova, A., Muhova, A., Palov, Iv., Stefanova-Dobreva, St. (2016). Study the effect of pre-sowing electromagnetic treatments on laboratory germination vigor and germination of seeds of bulgarian triticale varieties. *International Scientific and Practical Conference "WORLD SCIENCE", Proceedings of the III International Scientific and Practical Conference "Topical Problems of Modern Science and Possible Solutions"*, *6*(10-14), Dubai, UAE, 31–40.

Sirakov, K., Stoilova, A., Palov, Iv., Muhova, A. (2019). Study on the Effect of Presowing Electromagnetic Treatmenton the Number and Lengths of Roots and Lengths of Sprouts of Triticale Seeds the Cultivar Colorit. *International Journal of Innovative Approaches in Agricultural Research*, *3*(3), 446–479.

Palov, Iv., Sirakov, K. (2004). Results from yield research on maize obtained often pre-sowing electromagnetic treatment of old and new seeds. *Agricultural engineering*, res. Pap. 36 (3), Raudondvaris, Lithuania, 34-41.

Powell, A., Mattewa, S. (1984). Prediction of the storage potential of onion seed under commercial storage conditions. *Seed Science and Technology*, 12,2, 641–647.

Добрев, Д., & Патенова, Г. (2003). Нов сорт полски фасул Образцов чифлик 12, *Известия на Съюз на учените – клон Русе*, серия „Аграрни и ветеринарно – медицински науки", 2003, т. 4, 25–27.

Палов, Ив., Патенова, Г., Сираков, К., & Гинчев, Г. (2009). Резултати от предварителни изследвания на предсеитбени електромагнитни обработки на семена от фасул. *Селскостопанска техника*, XLVI, №4, 15–21.

Палов, Ив., Сираков, К., Кузманов, Е., & Армянов, Н. (2012). Резултаты исследования предпосевной электромагнитной обработки семян фасоли. *Техника в сельском хозяйстве*, Москва, №2, 6-7.

Палов, Ив., Стефанов, Ст. П., Златев Зл. Т., & Станковски, М. (1998). Метод за предсеитбена електромагнитна обработка на семена от фъстъци. Патент за изобретение № 42681, София.

Патенова, Г., Гинчев, Г., Палов, Ив., & Сираков, К. (2009). Резултати от предсеитбени електромагнитни обработки на семена от фасул. *Селскостопанска техника*, XLVI, №5, 20–25.

Реймерс, Ф., (1979). Биохимические и физиологические исследование семян. *Автреферат канд. дисс.* Иркутск, 1979, 7–17.

Сираков, К. (2006). Резултати от изследвания след предсеитбени електромагнитни обработки на царевични семена от български и американски хибриди. *Научни трудове на Русенски университет "Ангел Кънчев"*, т. 45, с. 3.1, Русе, 120–124.

Фурса, Т. Б. (1974). Изучение коллекции бахчевых культур. Труды по прикладной ботанике, генетике и селекции, *Российская сельскохозяйственная академия*, Ленинград, *53*(3), 282–287.