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POSSIBILITIES FOR INCREASING THE YIELDS AFTER PRE-SOWING ELECTRIC TREATMENT OF WHEAT AND MAIZE SEEDS

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Abstract. *Following many years of research, it has been determined that for the environmentally friendly stimulation of the growth of plants and increase of their yields, it is necessary to apply pre-sowing electromagnetic treatment to the seeds of these plants.*

A study has been carried out of the impact of the pre-sowing electromagnetic treatment of the seeds of different Bulgarian wheat varieties and of maize hybrids provided by Bulgarian producers and by the companies Pioneer-USA and the French Maisadour Semences.

At certain values of the controllable factors of the pre-sowing treatment, the following results have been achieved: an increase of (9…20)% in wheat yields as compared to the control batch, and an increase in the length of the maize ears, a higher number of leaves and a higher number of kernel rows in an ear, a higher number of kernels in a row, and yields increased by (5…21)% as compared to the control batch.

Key words: *maize and wheat seeds, pre-sowing electromagnetic treatment, increase of yields.*

INTRODUCTION. At present, the increase of yields in agricultural crops is secured by a whole set of measures concerning the post-harvest and pre-sowing treatment of the seeds. The analysis made of these types of treatment reveals that:

- notwithstanding a number of advantages, the mechanical treatment of seeds is not effective in selecting out only the biologically fit ones;
- the excessive use of chemicals in the pre-sowing treatment of seeds, and the fertilization with chemical fertilizers leads to irreversible consequences for nature and human health. In that sense, nature is constantly subjected to pollution.

We are also witnesses to the fact that there are now numerous fields so heavily polluted by heavy metals and fertilizers that the plants grown on such land and used to feed animals and humans have proven to cause severe health problems [19].

The foregoing underlies the search for new, environmentally friendly and energy-efficient approaches and ways to increase yields.

What possibilities are there for increasing the yields? It is a known fact that the living and non-living nature on Earth exist in the so-called Earth's electromagnetic field. That field has variable electric and magnetic components. It is also known that electric currents flow from the atmosphere to the ground and in the ground itself.

It can be concluded, therefore, that the described factors (Earth's electromagnetic field and electric currents to the Earth's surface) are immutable. In them, living nature is born, exists and develops.

A logical conclusion is that to increase the yields of agricultural crops, their seeds should be subjected to treatment that recreates the environment in which the plants exist.

Such conclusion can be supported also by the explanations given below.

The analysis of specialized literature reveals that plants, and their seeds in particular, can be regarded as electric objects [1,19] . This might be explained through the following facts:

- *it is known that seeds contain proteins.* Their elementary structural units are the α – amino acids that have an acidic carboxyl group, COOH and an alkaline amino group NH_2. Under certain external influences, the carboxyl group COOH ionizes. It releases its hydrogen atom *H* which can join any amino group NH_2. Therefore, the electric neutrality of the protein molecule is lost;

- seeds are stored at relative moisture of (10 ... 14)%. This moisture (bound, partially bound or free), albeit in small quantities, can be classified as a dipole, i.e. determined as an electrical object that can be subjected to the influence of electrical current, or electrical, magnetic, electromagnetic and the like fields;
- many seeds contain fats, vitamins, sugars, starch, cellulose, etc. To some extent they contain also acidic carboxyl groups COOH, OH groups, amino groups NH_2, etc., which suggests that under certain conditions the electric neutrality of cells is affected.

The foregoing brief analysis leads to the following conclusions:

As the interaction between living nature and the Earth's electromagnetic field that has been taking place for centuries has become genetically embedded in plants and seeds, to stimulate the latter, impact fields similar in nature to that of the Earth should be used.

Such stimulation is environmentally friendly – it does not pollute nature, the seeds, or the resulting produce. Moreover, it will create around the seeds an environment as close as possible to the natural conditions of an alternating electromagnetic field.

The preliminary analysis shows that in comparison with the various other fields (electrical, electrostatic, magnetic and electromagnetic) and radiation (X-ray, gamma, etc.) used until now, a more cost-effective option is the application of a 50Hz electromagnetic field at elevated voltage levels. Furthermore, it has been established through experiments that unlike the effect of radiation, the treatment in the described fields does not affect the seeds in a lethal way.

Based on the analysis of the Earth's electromagnetic field and the assumption that different types of seed material (seeds and tubers) can be regarded as electrical objects, studies have been carried out for over 30 years at Angel Kanchev University of Ruse, Bulgaria on the pres-sowing electric (electromagnetic and electrostatic) treatment of the seeds of agricultural crops. The studies have been conducted in cooperation with agricultural research institutes in Bulgaria, Hungary, Lithuania and other countries.

The purpose of this paper is to show some results of the joint research work of Angel Kanchev University of Ruse – Bulgaria with other scientific institutes in the field of the environmentally clean stimulation of the growth and yields of the basic agricultural crops in Bulgaria.

Types of seeds, pre-sowing electric treatment approach, and devices used. It is common knowledge that according to their content, seeds are divided into bread-making cereals and fodder crops that are collectively referred to as *cereals* in Bulgaria, and seeds *high in fat.*

The results of the long years of studies conducted at Angel Kanchev University of Ruse show that these two types of seeds react differently to pre-sowing electric impact.

For the purpose of the pre-sowing electric treatment, the seeds were divided in 3 groups: cereal seeds (wheat, maize, barley, etc.), seeds high in fat (cotton, sunflower, rapeseed, etc.) and seeds of vegetable crops. Potato tubers were classified in a different group.

Following theoretical [13,14,16] and experimental research, it was determined that the cereal seeds should be enabled to assume a position with their germs in the direction of the lines of force of the applied external electric field. For this purpose, a special screw device [3] was built. It represents a modified screw conveyor whose housing is lined on the inside with dielectric material. The metal screw of this conveyor is dielectrically insulated from the housing, which is connected to the protective neutral of the electrical system. Thus, the safe operation of the device is ensured.

It could be seen that the housing and the screw of the conveyor represented two electrodes insulated from each other. High AC voltage of several thousand volts and industrial frequency was applied to the electrodes. It created an electromagnetic field between the electrodes. As the screw rotated, the seeds were transported to the exit of the conveyor. Thus they were immersed in the created electromagnetic field and are enduring its impact.

After carrying out X-ray tests [13] with „marked" seeds it was established that in order to provide a possibility for the seeds to assume a position with their germs in the direction of the lines of force of the electric field 14], the screw device must be full up to 50% of its volume.

It was found that the device [3] could not produce an effective impact on seeds high in fat, e.g. cotton seeds, sunflower seeds, etc. An explanation for this would be the presence of the so-called "oil shield" against external influences. Another method of treatment, developed at Angel Kanchev University of Ruse, was used for this purpose [2].

METHODOLOGY OF THE STUDIES. The treatment of cereal seeds was done in the aforementioned device [3]. To optimize the number of tests and perform a mathematical processing of the obtained results, full factorial experiment (FFE) 2^2 was used. The selected controllable factors were: the voltage U, kV between the electrodes of the treatment device, and the duration of treatment τ,s.

It had been established experimentally that to cause internal changes in the seeds to occur, they should be left to rest for (14…40) days after the electromagnetic treatment and before being sown. To that effect, for examining the duration of rest – T days –between treatment and sowing, the so-called FFE 3^2 was applied, along with plan B_2 [8,9 etc.]

The field studies were conducted as the seeds were sown in fourfold or six-fold repetitions. The location for the different variants was determined according to [23].

The sowing of the seeds in the field and the plant care were carried out according to the adopted technologies in Bulgaria and Hungary.

RESULTS OF THE STUDIES

Some results of the studies of wheat seeds. The initial studies began on seeds of the Bulgarian wheat variety Pliska, and Line No.7 thereafter known as Venka-1 variety. The two wheat varieties have different vegetation periods. Pliska variety is classified as an early one, while Line No. 7 as a medium-early one. Both varieties possess good technological parameters and produce high yields. They were engineered at the *Institute of Agriculture and Seed Science IASS "Obraztsov chiflik" – Rousse.*

For over two decades, the wheat variety Pliska set the yield standard in Bulgaria.

For the pre-sowing electromagnetic treatment of the wheat seeds, the device [3] was used. The treatment was carried out in the second 10-day period of September, in an electromagnetic field with controllable factors: voltage U, kV и duration of impact τ,.s. These factors had lower limits of 1 kV, and 10s, and upper limits of 5kV, and 30s, respectively.

Untreated control seeds were also used in the studies. Their parameters were compared to the results obtained from the pre-sowing electromagnetic treatment under different values of the controllable factors.

The seeds were sown in the field on the 20th day after the treatment, in the first 10-day period of October, within the time limit set by the agronomic sowing requirements in Bulgaria.

Table 1 shows the values of the controllable factors for the pre-sowing electromagnetic treatment, and the results of the studies of the wheat yields.

From the data shown in Table 1 it can be concluded that there is a certain varietal dependency of the two types of wheat seeds toward the same type of pre-sowing electromagnetic treatment. The early Pliska variety produced an increased yield of 20% after the treatment with electrode voltage U=1kV and duration of treatment τ = 30s.

The medium-early wheat variety Venka-1 also produced an increased yield of 20% as compared to the control batch, but with electrode voltage U = 1 kV and duration of impact τ = 10 s.

With the applied high electrode voltage value of U=5 kV and duration of impact τ = 30s, a suppressing effect on the seeds of Pliska variety was found, and the obtained yield was 79,6%/c. In Line No. 7 such suppression resulted at the same voltage level, but at τ = 10 s – the yield was 78,4%/c.

Table 1. Controllable factor values and wheat yields after pre-sowing electromagnetic treatment of the wheat seeds

Variant No.	Controllable factors				Yield	
	Voltage,U		Duration of impact, τ		Pliska variety	Line No.7
	-	kV	-	s	%/c	%/c
1	+	5	+	30	79,6	103,4
2	-	1	+	30	120,4	*
3	+	5	-	10	110,2	78,4
4	-	1	-	10	108,5	120,6
5	Control batch, untreated seeds				100,0	100,0

**- the test has not been performed; %/c – as a percentage of the control batch*

The studies were continued jointly with the *State Agricultural Institute (DZI) General Toshevo, Bulgaria*, on wheat seeds of the Bulgarian varieties Enola and Kristy, which were created in the Institute.

The Enola variety is widely used in Bulgaria. Through the economic year 2013, the largest share of 39% of the annual wheat production in the country was formed by the Enola variety [4]. Since 2001, this wheat variety has been entered in the catalogue of varieties of the Republic of Macedonia.

The results of the joint studies showed that the values of the applied voltage U, kV may be selected as follows: 1kV, 1,65kV and 3kV. The duration of treatment was determined to be τ=10 s. The tests were carried out with the screw device [3] full at 50% (variants 1EM…3EM), and 5% (variants 4EM…6EM). Electrostatic treatment of the seeds was also performed, at voltages of U= 11kV and 7,5 kV (variants 7ES…8ES).

The data on the average yield of the wheat variety Enola, expressed as a percentage of the control batch (%/c), are shown in a graphical form in Fig.1 [20]

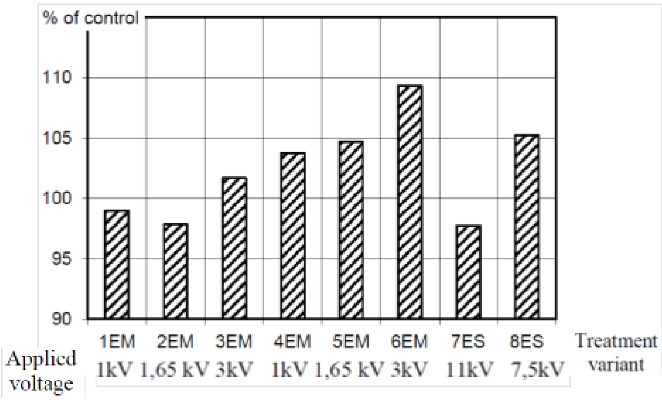


Fig.1. Results of the studies of the average yield (as a percentage of control)

Wheat variety Enola, with treatment variants: (1EM…3EM) – pre-sowing electromagnetic (EM) treatment with the device full at 50% [3]; (4EM…6EM) - pre-sowing electromagnetic (EM) treatment with the device full at 5% [3]; (7ES, 8ES) – pre-sowing electrostatic (ES) treatment

The analysis of Fig.1 shows that, depending on the level of fullness of the device [3] and the magnitude of the voltage U, kV, and for a duration of treatment of τ=10 s, the pre-sowing electromagnetic effect on the seeds turned out to be different.

Thus, with the screw device full at 50%, only for the variant 3EM (voltage U=3 kV) the yield was 1,70% higher as compared to the control batch, which made additional 105,7 kg/ha of grain to the yield.

In variants 1EM and 2EM the yields were lower as compared to the control batch and were 99,14%/c and 97,86%/c, respectively. Therefore, for a large quantity of seeds (i.e. 50% level of fullness of the screw device [3]) during the treatment, and comparatively low voltage levels (1kV and 1,65kV), the achieved effect on the seeds proved to be insufficient.

With the screw device full at 5% of its volume, there was a positive effect of the electromagnetic treatment. Thus, for variant 6EM (U=3kV) the obtained yield was by 9,32% higher than the control batch. This made additional 579,7 kg/ha of grain. For treatment variant 4EM, this additional quantity was 233,2 kg/ha, and for 5EM it was 293,6 kg/ha.

The treatment in the electrostatic field, at a lower voltage level of U=7,5kV, helped to obtain a yield of 105,25%/c. The use of an electrostatic field has some disadvantages as it requires higher voltage values and the used equipment creates certain technological difficulties which have been avoided in the device [3].

Some results of the studies of maize seeds. The long years of research [10,11,12 и др.] on the pre-sowing electromagnetic treatment of maize seeds using the device [3] show that at certain selected values of the controllable impact factors: voltage U, in kV and duration τ of treatment, in sec., it is possible to achieve accelerated growth, earlier ripening of the maize, and higher yields per unit of area.

Maize is a major feed grain in Bulgaria. For this reason, large-scale studies of its seeds are carried out. Planned experiments of the type $FFE2^2$, $FFE3^2$ and plan B_2 [9, etc.] are used for the purpose.

In [12,17] the results are given of the multi-annual studies of the pre-sowing electromagnetic treatment of seeds of the medium-early Bulgarian maize hybrid Ruse 424 [6] and the medium-late

Bulgarian hybrid Ruse 464 [5]. They were created at the *Institute of Agriculture and Seed Science (IASS) "Obraztsov chiflik" – Ruse*. Following an analysis of the results of the preliminary research on the electromagnetic treatment of maize seeds, the following impact factor levels were applied: for the voltage U: - lower level – 1,15 kV, medium level 1,65 kV and upper level 2,15 kV; - for the duration of impact of the electromagnetic field τ the selected values were within the range 2,5s up to 20s with an increment of 2,5s.

Studies were conducted also of seeds that were kept for several years after their production – conditionally called "old" seeds and "new" seeds – produced in the year preceding their electromagnetic treatment. For the purpose of the studies, seeds produced in the years 1999, 2000, 2001 and 2002 were used. The seeds were subjected to pre-sowing treatment in 2003 and were sown and grown in the field by the technology adopted in Bulgaria.

It was established that in the plants having emerged from treated seeds the ear was located at a lower height, which is a sign of early maturity. Furthermore, the data about the observed lower arrangement of the ear were less dispersed around its mean value as compared to the plants which emerged from untreated seeds. This is an indication that the pre-sowing electromagnetic treatment results in the equalization of the ongoing processes in the plants during their vegetation.

Thus, after several years of research, accelerated ripening of maize was achieved and along with that yields were obtained with statistically proven decreased relative moisture content of the grain; statistically proven increase in the maize yield of more than 19% as compared to the control batch, including similar stimulation in seeds having been kept for several years after their production.

The above result was achieved after treating the seeds in the device [3] at electrode voltage U=1,65kV, duration of impact τ=10s and period of rest of the seeds between the treatment and sowing T= (14…20) days.

The studies continued and an objective was set to determine the effect of the pre-sowing electromagnetic treatment carried out in the preceding year on maize seeds of the Bulgarian hybrids Ruse 424 and Ruse 464, as well as its effect on old seeds of the maize hybrid PR37H24 provided by the company Pioneer-USA [21]. The seeds of the American hybrid were produced in the remote to Bulgaria geographical region of Hungary.

The American maize hybrid PR37H24 and the Bulgarian one Ruse 424 are medium-early and belong to the group 400 according to FAO ***(Food and Agriculture Organization)***, while the Bulgarian Ruse 464 is medium-late.

The seeds of hybrid PR37H24 used in the experiment were produced in 2004 and were treated in the device [3] on 23 March 2006, i.e. after having been kept for 2 years until being subjected to the pre-sowing electromagnetic treatment.

The seeds of the hybrids Ruse 424 and Ruse 464 were likewise produced in 2004, but were treated in April 2005, and were kept for one year before being sown in 2006.

In the conducted studies it was established [21] that the internal changes which took place in the maize seeds after the pre-sowing electromagnetic treatment were of a lasting nature and were maintained for 1 year after the electrical impact had been applied.

After the pre-sowing treatment of the seeds of the Bulgarian hybrids Ruse 424 and Ruse 464 in the preceding year, as well as after the treatment of the "old" seeds of the medium-early American hybrid PR37H24, the following was achieved: an increase in the length of the ears of up to 12,3 %, a higher number of leaves – (2,3...18,1) %, an increased number of rows (by up to 10 %) in the ears, and an increased number of kernels in a row (2,4...13,1) %.

It was established that the impact of the pre-sowing electromagnetic treatment of seeds from one group according to FAO (400), which were produced in geographically remote rural areas of Bulgaria, was identical – higher yields were obtained with lower relative moisture content of the grain.

Experiments were performed [18] with the maize hybrid seeds of the medium-early Ruse 424 and the medium-late Ruse 464 and Ruse 555 [5,6,7] , which, after undergoing treatment in the device [3] were sown in three different locations under differing weather conditions in North-Eastern Bulgaria.

It was established that, as an average for the three experimental locations, in 80% of the variants that were subjected to electromagnetic treatment of the seeds, positive results were obtained.

By mathematical processing [8,9] of the registered results of the yield Y, regression models were built. The factor voltage of treatment U was assumed to be denoted by $\overset{\circ}{x}_1$, and the duration of impact τ - by $\overset{\circ}{x}_2$.

Shown below are the calculated models of the yields Y of the hybrids Ruse 424, Ruse 464 and Ruse 555, obtained in location III.

$$Y_{424} = 8220{,}60 + 93{,}654.\overset{\circ}{x}_1 - 400{,}49.\overset{\circ}{x}_2 + 356{,}50.\overset{\circ}{x}_1.\overset{\circ}{x}_2 - 1080{,}89.\overset{\circ}{x}_1{}^2 + 346{,}34.\overset{\circ}{x}_2{}^2 \quad (1)$$

$$Y_{464} = 9223{,}56 + 97{,}740.\overset{\circ}{x}_1 - 1030{,}45.\overset{\circ}{x}_2 - 878{,}75.\overset{\circ}{x}_1.\overset{\circ}{x}_2 - 161{,}310.\overset{\circ}{x}_1{}^2 + 158{,}175.\overset{\circ}{x}_2{}^2 \quad (2)$$

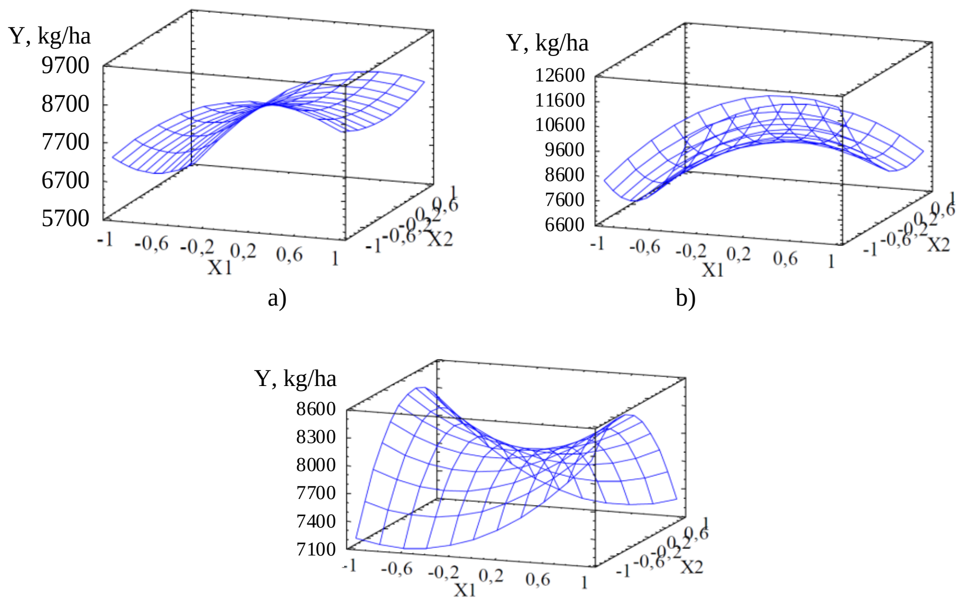
$$Y_{555} = 7990{,}06 + 38{,}17.\overset{\circ}{x}_1 + 11{,}08.\overset{\circ}{x}_2 - 472{,}25.\overset{\circ}{x}_1.\overset{\circ}{x}_2 + 43{,}228.\overset{\circ}{x}_1{}^2 - 69{,}424.\overset{\circ}{x}_2{}^2 \quad (3)$$

Similar are the yield equations for the other two geographical areas.

Their analysis reveals that the models are adequate and the different operators before some corresponding figures could be attributed both to the differing characteristics of the individual hybrids and to the different climatic conditions in the three locations where the maize was grown.

The surfaces which expressed the relationship between the expected yield and the different values of the controllable factors $\overset{\circ}{x}_1$ (voltage) and $\overset{\circ}{x}_2$ (duration of pre-sowing impact) were built. Fig.2 shows these surfaces for location III.

From Fig.2 it can be concluded that for the three tested maize hybrids the described surfaces are different in nature. It is another proof to the fact that controllable impact factors of equal values have a different impact on the seeds of the medium-early hybrid Ruse 424 and the medium-late Ruse 464 and Ruse 555.



c)

Fig.2. Surfaces, describing the interaction between the yield Y and the magnitude of the controllable impact factors $\overset{\circ}{x}_1$ и $\overset{\circ}{x}_2$ (for location III) for maize hybrids: a) Ruse 424; b) Ruse 464; c) Ruse 555

The analysis of the obtained results shows that:

- the three monitored maize hybrids react in a different way to the pre-sowing electromagnetic treatment of their seeds and this results in different yields under the same type of electric treatment.
- after the pre-sowing electromagnetic treatment the following was obtained:

a) an increase in the yield: for Ruse 464 – up to 12.47 %, and for Ruse 555 up to 14.61 % above that of the control batch;

б) increase in the mass of the harvested grain: for Ruse 424 – up to 11,8 %, and for Ruse 555 up to 5,9 % higher in comparison to the control batch.

In 2011…2013, in the fields by Ruse town, studies of the seeds of maize hybrids of the French company Maisadour Semences were carried out following their pre-sowing electromagnetic treatment. The hybrids were the medium-early MAS 47.P (440 according to FAO) and the medium-late LG 34.75 2012 (480 according to FAO). Here, too, the type of hybrid was found to depend on the value of the controllable factors. For example, at a voltage of U=1,65 kV and duration of treatment τ=10s, an increase of 5,1% in the yield was registered for hybrid MAS 47.P, and 22,5% for LG 34.75.

CONCLUSIONS

1. After many years of research it has been established that for environmentally clean stimulation of the growth of the plants and increasing their yields, pre-sowing electromagnetic treatment of the seeds must be applied.

2. The impact of the pre-sowing electromagnetic treatment of the seeds of different Bulgarian wheat varieties and maize hybrids provided by Bulgarian, North-American and French companies has been examined. A varietal and hybrid dependency of the seeds toward uniform pre-sowing electromagnetic treatment has been found.

3. At voltage level between the electrodes of the treatment device [3] U=1kV and duration of treatment τ = 30s, an increase of up to 20% in the yield of the early Bulgarian wheat variety Pliska has been achieved. With the variety Venka-1 the same increase in the yield has been achieved at U=1kV and τ = 30s.

4. For the wheat variety Enola, an increase of more than 9% in the yield has been achieved at voltage level between the electrodes of the treatment device [3] of U=3kV, and duration of treatment τ = 10s.

5. It has been established that after pre-sowing electromagnetic treatment of the seeds of maize hybrids, the ears of the emerged plants are located lower on the stem than those of the control batch, which is a sign of early ripening.

7. It has been established [21] that the internal changes having occurred in the maize seeds after the performed pre-sowing electromagnetic treatment are of a lasting nature and stay for one year after the electric treatment. Furthermore:

a) after the pre-sowing electromagnetic treatment of the seeds of the Bulgarian hybrids Ruse 424 and Ruse 464 in the preceding year, and also after the treatment of old seeds of the medium-early American hybrid PR37H24 (400 according to FAO) of Pioneer-USA, the following has been achieved: increase in the length of the ears of up to 12,3 %, higher number of leaves – (2,3...18,1) %, an increased number of up to 10% of the rows in an ear, and an increased number of kernels in a row (2,4...13,1) %.

b) the same impact has been observed of the pre-sowing electromagnetic treatment on seeds belonging to the same group by FAO (400) but produced in geographically remote areas: higher yields are obtained with lower relative moisture content of the grain.

6. After the pre-sowing electromagnetic treatment of seeds of the Bulgarian maize hybrids Ruse 464 and Ruse 555, accelerated ripening of the maize has been achieved, and along with that, yields have been obtained with statistically proven decreased relative moisture content of the grain; statistically proven increase in the maize yield of more than 14% as compared to the control batch, including similar stimulation in seeds that had been kept for several years after their production.

7. After pre-sowing electromagnetic treatment at a voltage of U=1,65 kV and duration of treatment τ=10s, of the seeds of maize hybrids of the French company Maisadour Semences: the medium-early MAS 47.P (440 according to FAO), and the medium-late LG 34.75 2012 (480 according to FAO), an increased yield has been achieved of hybrid MAS 47.P by 5,1% and of hybrid LG 34.75 by 22,5%.

REFERENCES

1. Andonov K., Hr. Ganev, Iv. Palov, V. Stefanov, St. P. Stefanov, Electrical technologies in agriculture. Zemizdat, Sofia, 1987 (in Bulgarian).

2. A method for a pre-sowing electromagnetic treatment of seeds of peanuts. Patent for the invention № 42681, and 01 1/00. Licensee: Iv. Palov, St. P. Stefanov, Ch. Ganev, Zl. T. Zlatev, M. Stankowski (in Bulgarian).

3. Apparatus for pre-sowing electrical treatment of sowing material. Patent for the invention № 30631, A 01 C 1/00 Licensee: P. Terziev, I. Palov, St. Stefanov, R. Radev (Bulgarian)

4. Ministry of Agriculture and Food, 2013. Forecast yields of wheat and barley before harvest 2013 Department "Agricultural Statistics", №247 / 06. (in Bulgarian).

5. Mitev S., Pl. Mitev, P. Gornishka, Ruse 464 - a new medium-early maize hybrid. Plant Science, Sofia, Bulgaria, 1993,1-4, p.76-78. (in Bulgarian).

6. Mitev S., Pl. Mitev, G. Hristova, P. Momchilova, Ruse 424. Plant Science, 35, Sofia, Bulgaria, 1998, p. 354-357. (in Bulgarian).

7. Mitev S., Pl. Mitev, G. Hristova, P. Momchilova, Ruse 555. Plant Science, 35, Sofia, Bulgaria, 1998, p. 358-360 (in Bulgarian).

8. Mitkov At., S.Kardashevski, Statistical methods in agricultural engineering. Zemizdat, Sofia, Mashinostroenie, Moscow, 1987. (in Bulgarian).

9. Mitkov At., D. Minkov, Statistical methods of research and optimization in agricultural engineering, Parts I and II, Zemizdat, Sofia, 1989, 1993, 367 p. (in Bulgarian).

10. Palov Iv., Chr. Andreev, E. Kouzmanov, N.Armyanov, Rezults from pre-sowing electromagnetic treatment of maize seeds, Agricultirall Engineering, Res. papers 33 (3), Raudondvaris, Lithuania, 2001, P. 43…52.

11. Palov Iv., A. Pozeliene, E. Kouzmanov, Chr. Andreev, Pre-sowing electromagnetic treatment of maize seeds, Energy efficiency and agricultirall Engineering, Proceedings of the union of scientists - Rousse, Bulgaria, 4-6 April, 2002, vol. 2, P.202…207.

12. Palov Iv., Studies of maize yields after pre-sowing electromagnetic treatment of the seeds obtained from different harvests. Agricultural Engineering, XL, 2003, No.5, p. 170-172. (in Bulgarian).

13. Palov, Iv., K. Sirakov, D. Iliev, Results of the study of the movement of maize seeds in a pre-sowing electromagnetic treatment device. Proceedings of Angel Kanchev University of Ruse, v.41, s.1.1., Ruse, 2004, p. 90-94.

14. Palov, Iv., K. Sirakov, E. Kalcheva, Analysis of the movement trajectory of the seeds in a pre-sowing electromagnetic treatment device. Proceedings of Angel Kanchev University of Ruse, v.41, s.1.1. Ruse, 2004, p. 95-98.

15. Palov Iv., N. Armyanov, K. Sirakov, Research on the electric field arising in maize seeds during their pre-sowing electromagnetic treatment, “Energy efficiency and agricultural engineering”, second conference, Procedings of the union of scientists, Rouse, Bulgaria, 2004.

16. Palov Iv., N. Armyanov, K. Sirakov, Research on the electric yield arising in maize seeds during their pre-sowing electromagnetic treatment // Energy efficiency and agricultural engineering, Second conference, Proceedings of the union of scientists, Rousse, Bulgaria, 2004, p. 601-606. (in Bulgarian).

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

18. Palov Iv. K. Sirakov, G. Nikolova, Pl. Mitev, G. Hristova, Pre-sowing electromagnetic seed treatment impact on maize hybrid yield // Agricultural engineering, Proceeding of the International Conference, New technological Processes And Investigation Methods For Agricultural Engineering N10, Raudondvaris, Lithuania, 2005, p. 327-334.

19. Palov Iv., St. Stefanov, K. Sirakov, Em. Kuzmanov, Y.Neikov, Increasing the production of grain and technical crops biomass by preliminary electromagnetic treatment of seeds // Publishing house “Leni AN-Rousse, Bulgaria, Ireland, Denmark, Hungary, Biomass Mobilizacion, EU Project № 245449, 2010, No 1, pp. 64-79, ISSN 978-594-8190, (in Bulgarian and English).

20. Palov Iv, A. Stoilova, K. Sirakov, Sv. Zahariev, Increasing of yields by pre-sowing electrical treatments of seeds of field crops // International Conference on “NEW APPROACHES IN FOOD SECURITY AND VALUE, Agra, India, (17-19).20.2014.

21. Sirakov, K., Results of the studies after pre-sowing electromagnetic treatment of maize seeds of Bulgarian and American hybrids. Proceedings of Angel Kanchev University of Ruse, v.45, s.3.1., Ruse, 2006, p. 120-124. (in Bulgarian).

22. Sirakov K., V. Dochev, Iv. Palov, Results from preliminary studies on pre-sowing electromagnetic seed treatment of wheat // Scientific Works of Rousse University "Angel Kunchev", vol. 46, 3.1., Rousse, 2007, pp. 87-91 (in Bulgarian).

23. Shanin, J.D., Methods of field experiment, Bulgarian Academy of Sciences, Sofia, 1989 (in Bulgarian).