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APPLICATION OF LOW FREQUENCY ELECTROMAGNETIC WAVES (LFEV) AND BIOLOGICAL INPUTS IN THE PRODUCTION OF SOYBEAN

SUMMARY

Examination of the impact of electromagnetic fields on function of biological systems is more recent direction in agriculture. Application of electromagnetic waves on seed activates the enzyme complex which results in better germination and growing. The aim of this study was to investigate the use of different groups of microorganisms and low-frequency electromagnetic waves to achieve high yields. The study was conducted at the experimental field of the Institute of Field and Vegetable Crops in Novi Sad. Valjevka soybean variety was used. Necessary nutrients were provided by use of poultry manure in amount of: control, 750 and 1300 kg.ha⁻¹ and incorporated mixture of useful microorganisms. Sub-plots include treatment of seeds with electromagnetic waves (15 Hz frequencies of exposure for 30 minutes) and the foliar treatment of plants with mixture of beneficial microorganisms in two growth stages of development. In the stage of development R₃ were defined the basic parameters of the biological value of the soil, and achieved a high yield in the harvest. The results showed significant increase of soybean yield (21.4%) in the version with electromagnetic waves. The highest yield of 3179 kg.ha⁻¹ was achieved in fertilization with 750 kg.ha⁻¹ and use of electromagnetic waves, which was also in 4.44%, or 124 kg.ha⁻¹ higher yield compared to the version without radiation. The results of investigated biogeny parameters of soil were compatible with soybean yield.

Keywords: soybean, fertilization, electromagnetic waves, yield, microorganisms

INTRODUCTION

Soy bean is a plant species that has great economic importance because of the chemical composition of the grain. Namely the grain contains 40% protein, 20% oil, and more than 60% of the nutrients in a variety of useful purposes. Soybean contains

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B complex vitamins, beta-carotene, it is rich in minerals, mainly calcium, iron and potassium. Soybean occupies 40% of the total world production of oil and has an important place in the food industry. Because of its high protein content, it is used as animal feed. At the beginning of the twentieth century, was a little-known plant, and today has an important place in the international trade in organic agricultural production (Hrustić i sar; 2006). The development of industry has contributed to today's strains and is represented in nearly 20.000 different food products intended primarily for children. Soybean has the ability to live in symbiosis with nodule bacteria of the genus *Rhizobium spp.*

Technological measures production in organic agriculture preserve basic resources of water, air, biodiversity and land. These measures primarily keep the soil from degradation by using inputs that encourage biological processes of circulation of matter and energy flow, thereby maintaining balance in the ecosystem, as well as the preservation of its health. It also creates conditions that plants under arbitrary optimal conditions, synthesize and accumulate characteristic of matter, the species and varieties, which provide a natural smell, taste, often intense color and higher sugar content, vitamins and carotenoids, a lower content of harmful substances.

In the increasingly complex demands of producing safe food, as an alternative to some chemical compounds, the solutions are in the field of biophysics. As a relatively new science, biophysics is of great importance for agricultural production. Application of E-treatment (electromagnetic waves of low frequency or low energy electrons) is in the initial phase of implementation in our country. Until 15 years ago, many researchers did not believe that low-frequency electromagnetic waves can affect the plants. Research of Marinković *et al.* (2000) on the effects of electromagnetic waves on the growth of wheat seedlings gave positive results. Today, on the basis of many studies clearly can identify positive changes occurring in plants. Most researchers agree that the cell membrane is the primary place where happens all this interaction, and a process is still continuing in the cell. According to research, Marinković *et al.* (2002), electrons are ejected from the cathode through the free atmosphere and act to awake electrons in seed, which causes faster germination and seedling growth. Similar results got Malešević *et al.* (2002) who explored impuls of resonant electromagnetic stimulation and its contribution to the production of wheat, while Lažetić *et al.* (1990) examined the impact on development of wheat germ.

Given that the world's tendency to expand the area of genetically modified soybeans in order to achieve larger and more stable yields, the goal of this study was to investigate the use of different groups of microorganisms and low-frequency electromagnetic waves to achieve high yields as well as the preservation and protection of the environment.

MATERIAL AND METHODS

The experiment was set up in four replications on soil type chernozem at the experimental field of the Institute of Field and Vegetable Crops in Novi Sad. In research soybean Valjevka was used, group 0, the length of growing season to 120 days. To provide necessary nutrients granular poultry manure formulations were used: control (no fertilizer), 750 and 1300 kg/ha-1st. Subplot seed

treatment include electromagnetic waves (15 Hz frequencies of exposure for 30 minutes) and the foliar treatment of plants with a mixture of beneficial microorganisms in the two growth stages of development. The mixture of beneficial microorganisms contained the following types of microorganism *Lactobacillus plantarum*, *Lactobacillus casei*, *Streptococcus lactis*, *Rhodopseudomonas palustris*, *Rhodobacter sphaeroides*, *carevisiae*, *Saccharomyces*, *Candida utilis*, *Streptomyces albus*, *Streptomyces griseus*, *Aspergillus oryzae*, *Mucor hiemalis*.

At the end of the growing season biological value of the soil was determined by the number of individual systematic and physiological groups of microorganisms on selective media by standard microbiological methods (Pochon and Tardieux 1962). Also, there is a yield of soybeans at 13% of moisture.

RESULTS AND DISCUSSION

The sustainable agriculture of 21 century is expected to rely on other scientific fields such as biophysics. The results showed that the effect of resonance pulse electromagnetic stimulation of seeds has different impact on parameters of biological value of soil and seed yield of soybean.

Microorganisms are the most numerous group of organisms in the soil that are actively involved in the degradation of organic and inorganic compounds and the circulation of matter, which keep the quality and accuracy of the soil. Due to react, its abundance and enzymatic activity, the presence of pollutants are a good indicator of changes in soil (Cvijanović et al 2006). Microorganisms provide an informative assessment of the health of the soil and ecotoxicity (Milosević et al.2000). In order to the number of useful microorganisms maintained on a high level it is necessary to use the methods for manufacture of food products which promote the growth and speed of biochemical response of these groups of microorganisms. One of the primary methods of plant nutrition is the use of biodegradable organic fertilizers. If they are of animal origin containing a larger amount of the lipid, protein, polysaccharide this contributes to increase of heat in the soil, and the dynamics of the number of microorganisms.

The total number of bacteria and their composition, is an important indicator of the overall biological value of the soil. An increase in their number indicates the changes that occur in the soil, the speed and intensity of decomposition of pollutants, as well as the intensity of mineralization of organic matter of the process, that depends on the inputs in the course of manufacture.

In the variant without radiation of soybean seeds (Table 1), the total number of microorganisms was lower ($226.57 \times 10^7 \text{ ha}^{-1}$) relative to a variation of the seed radiation ($235.97 \times 10^7 \text{ ha}^{-1}$). Compared to the control, the total number of microorganisms in the first embodiment was increased by 9.81%, whereas in the second variation increase was 4.26%.

Table 1. The number of microorganisms in the rhizosphere soil without radiation of soybean seed

Variants	Azotobacter		The total number of microorganisms		Fungi		Cyanobacteria	
	10^2 ha ⁻¹	I.N.	10^7 ha ⁻¹	I.N.	10^4 ha ⁻¹	I.N.	10^4 ha ⁻¹	I.N.
Control	9.2	100	206.3	100	17.90	100	3.93	100
Control + foliar treatment	16.1	176	216.3	121.4	10.53	58.8	3.23	82.2
750 kg.ha ⁻¹ poultry manure + foliar treatment	23.8	260.3	250.4	115.8	14.67	139.3	13.30	338.4
1300 kg.ha ⁻¹ poultry manure + foliar treatment	0.00	0.00	212.9	103.2	11.23	62.7	6.07	154.5
Average	12.3	145	226.5	109.8	13.58	67.8	6.63	191.7

Azotobacter is very important group of bacteria that fix atmospheric nitrogen and transforms it into a form that is available for plants. It is also an important parameter for determining biological value of the soil. This group of bacteria is very sensitive to any changes that occur in the soil and reacts with its number and activity. Based on the results it was observed that their number in variants with radiation was higher ($13.14 \times 10^2 \text{ ha}^{-1}$) (Table 2), than without radiation ($12.30 \times 10^2 \text{ ha}^{-1}$) (Table 1). In the variant without radiation with doses of 1300 kg.ha^{-1} organic fertilizer, their number was not determined, while in the variant with radiation determined by the smallest number of groups of microorganisms.

Table 2. The number of microorganisms in the rhizosphere soil with application of electromagnetic waves (EMW) in soybean seed

Variants	Azotobacter		The total number of microorganisms		Fungi		Cyanobacteria	
	10^2 ha ⁻¹	I.N.	10^7 ha ⁻¹	I.N.	10^4 ha ⁻¹	I.N.	10^4 ha ⁻¹	I.N.
Control + EMW	3.37	100	226.3	100	6.6	100	7.9	100
Control + foliar treatment + EMW	25.1	745.7	241.3	106.6	22.7	343.9	9.2	115.4
750 kg.ha ⁻¹ poultry manure + foliar treatment + EMW	12.5	370.0	236.2	104.3	12.3	186.3	25.7	322.4
1300 kg.ha ⁻¹ poultry manure + foliar treatment + EMW	1.8	54.3	230.4	101.8	23.6	357.1	2.9	36.0
Average	13.1	390.0	235.9	104.3	16.3	246.8	11.4	143.4

In both variants in the amount of $1300 \text{ kg}\cdot\text{ha}^{-1}$ organic fertilizer bacterial count of *Azotobacter* group was the lowest. Larger amounts of nitrogen can inhibit free nitrogen fixation, because the presence of large amounts of nitrogen inhibits the synthesis of the enzyme nitrogenase.

Fungi and Cyanobacteria actively take part in the biochemical processes that are connected in a chain and affect the degradation of difficult to degradable organic substances. Chemical elements and energy that is then released influence the prolonged duration and maintain fertility and soil quality.

They are able to decompose in the soil polysaccharides, starch and glycogen (Šutić and Radin 2001). Their number depends on the amount of organic matter that enters the soil. Fungi is an important factor in the total biomass of soil. Based on the results it was found that the greater number of these groups of microorganisms was in the variant with the radiation ($16.29 \times 10^4 \cdot \text{ha}^{-1}$) (Table 2).

Cyanobacteria are the primary producers of organic matter, which enrich the soil and improve its fertility. With the help of photosynthetic activity, they produce organic matter and then release oxygen. The released oxygen is available to aerobic microorganisms which increases the intensity of decomposition of organic matter and availability of mineral elements to plants. In the E-treatment number of cyanobacteria ($11.43 \times 10^4 \cdot \text{ha}^{-1}$) was higher than the 72.3% in the treatment without electromagnetic waves.

Also, it has been found an increase of all the group of microorganisms as compared to the control in both variants of the experiment. It can be said that the application of foliar plant treatment with effective microorganisms (Table 1) gave positive results for all groups of organisms with their number responded positively.

Stimulation of plant growth is affected by the increase in mass of the root system which increases the amount of excreted substances in the rhizosphere soil, which significantly affects the dynamics and the biochemical activity of microorganisms (Cvijanovic G. 2002). Marinković et al in (2002a) found that having different exposure time EMW caused increase in the weight of the root system of corn in 37% (28 mg per plant), and the above-ground part of the plant by 31%, or 22 mg per plant.

Yields were different in variants. In the E-variant, yield was in average $3169.25 \text{ kg}\cdot\text{ha}^{-1}$, while in the variant without EMW yield was $3061.58 \text{ kg}\cdot\text{ha}^{-1}$. The difference in yield was 3.51%, at the level of statistical significance of 1% (Table 3).

In similar surveys conducted by Milošev and Šeremšić 2005, with EMW 30Hz intensity and exposure time of 30 minutes caused increase of yield components in wheat. Crnobarac et al 2002 found increase in the yield of sunflower $222\text{-}390 \text{ kg}\cdot\text{ha}^{-1}$, soybean $306\text{-}658 \text{ kg}\cdot\text{ha}^{-1}$ while Milos et al. 2001 found increase in yield components and biological traits in barley by the action of electromagnetic waves.

Table 3. Yields of soybean seed at the end of the growing season (kg.ha⁻¹)

Variants (A)	Fertilization (B)	AxB	Average (A)
Without the use of electromagnetic waves	Control	2878.00	3015.69
	Control + foliar treatment	3043.75	
	750 kg.ha ⁻¹ poultry manure + foliar treatment	3078.25	
	1300 kg.ha ⁻¹ poultry manure + foliar treatment	3062.75	
With the use of electromagnetic waves	Control	3063.25	3142.69
	Control + foliar treatment	3179.0	
	750 kg.ha ⁻¹ poultry manure + foliar treatment	3125.25	
	1300 kg.ha ⁻¹ poultry manure + foliar treatment	3203.25	
Average (B)	Control	2970.25	3079.19
	Control + foliar treatment	3111.37	
	750 kg.ha ⁻¹ poultry manure + foliar treatment	3101.75	
	1300 kg.ha ⁻¹ poultry manure + foliar treatment	3133.00	
Average yields		3079.19	

LSD	A	B	AxB
5%	24.41	37.55	53.11
1%	44.80	51.45	72.76

CONCLUSIONS

Microorganisms were introduced into the soil before sowing and foliar treatment. The main parameters of the biological value of the soil (the total number of microorganisms, *Azotobacter*, fungi and cyanobacteria) were increased compared to control. In the variant with radiation before sowing the studied parameters were higher compared to the same variant without radiation and in comparison to the control. Increasing the parameters ranged from 6.8% azotobacter, 4.4% of the total, 19.95% of the fungi and the largest increase in number was found in cyanobacteria 72%. Electromagnetic waves that were used for exposure of seeds before sowing give better results in number and activity of the principal groups of the biological value of the land.

The yield of soybean was higher in both cases compared to control, while the variant with the EMW was 4.21% higher yield than the embodiment without electromagnetic waves.

Applying this technology with using organic and microbial fertilizers may affect the maintenance of soil fertility and achieving high yields of plants.

The use of low frequency electromagnetic waves offers great opportunities to conserve soil and achieving high yields, but the advantages and disadvantages of their use, must be identified.

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