THE IMPORTANCE OF BIOFERTILIZERS IN SUSTAINABLE PRODUCTION OF CORN, WHEAT AND SOYBEAN

Gorica CVIJANOVIĆ[1], Ordana DOZET[2], Vojin ĐUKIĆ[2], Nenad ĐURIĆ[4]
[1] Full professor, Faculty of Biofarming Bačka Topola, University of Megatrend Beograd, email: cvijagor@yahoo.com
[2] Associate Professor, Faculty of Biofarming Bačka Topola, University of Megatrend Beograd, email: gdozet@biofarming.edu.rs
[3] Research Associate, Institute of Field and vegetable Crops, Novi Sad, email: vojin.djukic@ifvcns.ns.ac.rs,
[4] Docent, Faculty of Biofarming Bačka Topola, University of Megatrend Beograd, email: nenad.djuric@outlook.com

Abstract
The European Union has adopted Agenda 2000 reform package, which defines the extent of agricultural production, whose concept of the production of biologically safe food and environmental and economic impact. Proper fertilization is one of the preconditions for the production of healthy food. Therefore, in recent decades, increasing attention is paid to the results of biological nitrogen fixation. This is a natural process which is not only significant but also in a biological practical sense. In the production of basic agricultural crops (corn, wheat and soybean) reduced consumption of mineral fertilizers is very important for the economic viability of production and environmental protection. Numerous studies have shown that the application of biofertilizers reduced use of mineral fertilizers to 60 kg.ha $^{-1}$ and influences the increase in the quality of land for the plant.
Keywords
mineral fertilizers, biofertilizers, soybeans, maize, wheat

Introduction

The main characteristic of agricultural production in recent decades was the intensification of inputs to achieve the cost-effective and yields a profit. In the eighties in crop production are introduced, new cultivars and hybrids with high genetic potential of fertility. Thus, the production of food into a form of industrial production, which demanded irrational use of fossil energy and created synthetic products. All this caused disturbances in the biological balance especially in agroecosystem. The main negative effects that accompany intensive farming are reflected in the erosion and land degradation in the reduction of biodiversity. Such food production has led to environmental degradation, and the result is less safe food, biologically high-value. These were the main reasons that encourage the development and improvement of methods for economically sustainable agricultural production. The use of mineral fertilizers is economically advantageous and fastest way to increase the yield in plant production. The importance of application of mineral fertilizers in crop production from the fact that their consumption in the world in the period 2002-2009. totaled 79.154.776,00 t - 92.040.356,00 t.

Intensive agricultural production requires the use of high technology in land preparation, nutrition and protection of plants. In this production with a view to achieving maximum yield using large amounts of mineral fertilizers. Nitrogen fertilizers have the greatest effect on the yield of plants and the negative effect on the elements of the environment (Marchner & Römheld, 1992). From incorporated amounts of mineral fertilizers, 50% of the plants are adopted, and the rest is transformed and lost from the soil.

From the aspect of environmental protection and cost-effective production in practice are increasingly used the research results of dietary supplementation of mineral fertilizers. One possibility is the use of microorganisms as biofertilizers in different microbiological preparations.

1. The importance of biofertilizers in sustainable crop production

In a system of sustainable production - organic farming, more and more are represented results of research in the biological sciences. In order to stimulate natural biological cycles (cycles of biogenic elements) increasingly apply different groups of microorganisms. The most important role is played by groups which can be used as biofertilizers, biostimulators and biopesticides. Considering the fact that the nitrogen is one of the necessary elements to achieve a stable, cost-effective and economic yields, requires large amounts of mineral nitrogen. The amounts are usually higher than the required quantities and their transformation often found as pollutants in the environment. These are the reasons that lead to the practical application of micro-organisms whose life activities fixing atmospheric nitrogen. Such groups are known as symbiotic and free nitrogen fixers (*Rhizobium, Azotobacteraceae*). The group biofertilizers include microorganisms, which releasing into the soil phosphorus (*Bacillus megaterium vr. phosphaticus*) and potassium (*Bacillus circulans*) from organic matter, making these elements available to plants. They can also be used associative groups of microorganisms which produce substances for plant growth (plant growth promoters). New techniques for preparing of preparations are so called, multiple inoculants. They contain different effective strains of the micro organism of the same species or different species with highly-effective strains. The application of these products can be reduced or completely absent mineral fertilizers.

Corn, soybeans and wheat are one of the most important cereal crops in the world. Maize production in the world in 2013. amounted to 1,018 millions of tons, 716 millions of tons of wheat, and soybeans 276 mil.t. For such a big production it is necessary to import large amounts of mineral fertilizers. Due to their negative impact on the elements of the environment, is increasingly include findings from biological nitrogen fixation, and commercial application of microbiological preparations. According to the Republic Bureau of Statistics harvested area by soybeans in Serbia in 2014. was 154,249 ha with an average yield of 3.5 $t.ha^{-1}$.

Special specifics in soybean production is the possibility of symbiotic relationship with bacteria of the genus *Rhizobium sp., Bradyrhizobium japonicum* which binds atmospheric nitrogen and thus meets the needs of 80% of plants for nitrogen. Application of microbiological fertilizers containing cells of these bacteria, reduces the use of expensive mineral fertilizers, reduces the cost of production, and are encouraged in soil processes that prevent land degradation. According to research Najdanovska (2001) the application of such of preparations in the production of potatoes and tomatoes, may be replaced by 60 $kg.ha^{-1}$. According to research Cvijanović (2007) in the production of maize and wheat using associative nitrogen-fixing may be replaced by 30-40 $kg.ha^{-1}$.

In addition, it can replaced 20-30 $kgN.ha^{-1}$, and can of synthesising many biologically active substances, products of organic acids which decompose phosphates, which significantly increases yields. Besides nitrogen fixing as biofertilizers using the bacteria and fungi that plants provide other nutrients (P_2O_5 and K_2O), carry out transport of nutrients from deeper soil layers and synthesize growth stimulators type of auxin, cytokinins, vitamins B group.

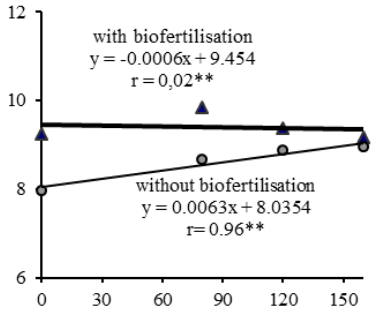
Using these biofertilizers in crop farming meet the standards GlobalGAP. Preserves the soil quality and meet the principles of economy and ecology that constitute a part of the National Programme of the EU in sustainable development.

Corn and wheat in Serbia are very significant cultures and occupy the largest area. In 2014. corn occupying a total of 1,057,877 ha and 604,748 ha of wheat. Average corn yields were 7.5 t.ha^{-1}, and wheat 3.5 t.ha^{-1}.

To achieve high, stable, viable economic yield per unit area nitrogen has an irreplaceable role. Therefore, the consumption of nitrogen in the world in the past 30 years increased by 27%. Many authors point out that the effect of ingested nitrogen has negative consequences for the ecosystem. In the surface watercourses is increase amount of nitrate nitrogen. The amount of nitrate nitrogen in the Danube through Serbia is on the fourth place of the 13 countries belonging to the Danube Region. All this points to the necessity of use of different groups of microorganisms that play a role biofertilizers. The microbiological preparations are typically used biofertilizers same species with a larger number of strains. Recent research based on the use of products with multiple larger number of species of microorganisms. In order to determine the effect of a mixture of different types of biofertilizers in the production of corn, research conducted soil type carbonate chernozem with fertilization of 60, 80, 120, 150, 160 kgN.ha^{-1} and sowing corn FAO 600-700 (ZP 684) and FAO 300-400 (ZP 434) the selection of the Institute of Maize Zemun Polje Serbia. Corn seeds were inoculated with a mixture of (*Azotobacter chroococcum, Azospirillum lipoferum, Brijerinckia Derx, Klebsiella planticola, Azotobacter vinelandi, Pseudomonas Bacillus magaterium* and *Bacillus subtillis*). Based on the obtained results, it was found that high doses of mineral fertilizers and application of biofertilizers had a negative impact on yields. The highest yield was detected in ZP 684 was at fertilization with 80 kgN.ha^{-1} (Figure 1). The regression line shows that the yield stabilizes at fertilizing with 80-120 kgN.ha^{-1}.

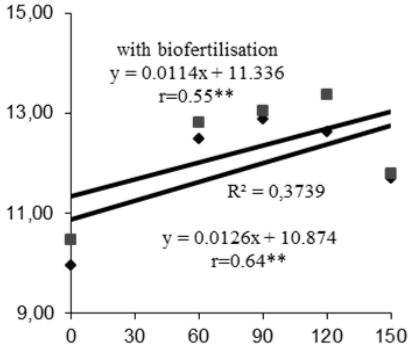
In the hybrids FAO 300-400 regression line is more pronounced. Maize yield without inoculation and fertilization with 150 kgN.ha^{-1} has a pronounced decline. The average yield of the hybrid ZP 434 with biofertilizers was 12.29 t.ha^{-1}, which was 3.02% higher than in variant without biofertilizers.

FAO 600-700



Rarates of mineral nitrogen kg.ha^{-1}

FAO 300-400



Rates of mineral nitrogen kg.ha^{-1}

Source: research author

Fig. 1 Dependence of maize hybrid yields on the application of biofertilisers, bacterisation and rates of mineral nitrogen

In addition to increasing yields, biofertilizers also affect grain quality. Long-term studies on effects of inoculation with biofertilisers show the identical effect on the maize grain protein content and applied rates of mineral nitrogen. The application of biofertilizers influenced the increase of protein in the grain of both varieties. This is important in the diet of farm animals.

The highest values of protein (10.07%) were determined at fertilization with 120 kgN.ha^{-1} (Table 1).

Table 1 Effects of bacterisations on total proteins in maize grain

	Proteins	Fertiliser rates kgN.ha^{-1}				Average
		0	80	120	160	
Inoculated	%	8.87	9.44	10.07	9.98	9.59
	Index level	110.32	108.00	109.10	109.19	109.22
Uninoculated	%	8.04	8.74	9.23	9.14	8.78
	Index level	100.00	100.00	100.00	100.00	100.00
		LSD 5%		LSD 1%		
Inoculation **		0.176		0.269		
Inoculation xFertilisers**		0.188		0.274		

Source: research author

In studies of 2010-2012 the effect of application of biofertilizers and different doses of mineral nitrogen on wheat yield, the obtained results were correlated with the results obtained in maize. In the research was presented wheat variety Pobeda the selection of the Institute of Field and Vegetable Crops Novi Sad Serbia. The results are correlated with investigations inoculation of wheat seed with Azotobacter (Mićanović et al., 2008). Based on the regression line (Figure 2) it was found that with increasing amounts of mineral nitrogen increases and the amount of yield and in a variant with and without bacterization. When using inoculation were determined higher yields r = 0.98* by all levels of fertilization than without bacterization r = 0.81*.

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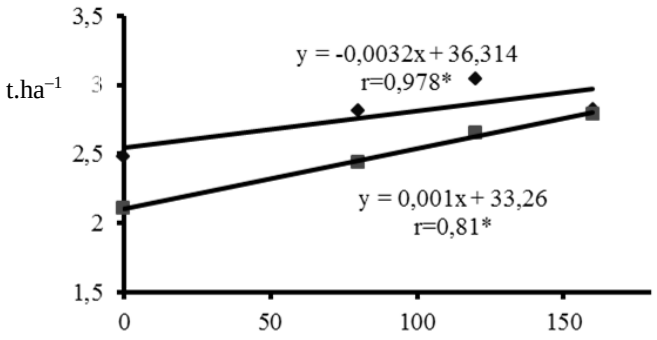

Mineral nitrogen rates kg.ha⁻;
r = 0.98* – coefficient of correlation in the variant with bacterisation;
r = 0.81* – coefficient of correlation in the variant without bacterisation
Source: research author

Fig. 2 Wheat yield in dependence on bacterisation and different mineral nitrogen rates

Besides contents of carbohydrates and starch, the protein content of wheat grain is also very important for wheat utility in bread production, as 75% of human population use bread in their diet. Studies performed on bacterisation of wheat with *Azotobacter* (Sarić and Delić, 1988), and on bacterisation of wheat with *Azospirillum* (Zambre et al., 1984) show the protein increase in grain. During the three-year studies, bacterisation and fertilisation significantly increased the protein content, while their interrelation did not affect it at the level of statistical significance (Cvijanović et al. 2008) (Table 2).

Table 2 Effects of bacterisation and N fertilisation on protein contents in wheat grain

Effects of year, bacterisation and fertilisation on protein contents in wheat grain						
Factor A	Factor B	Factor C: fertilisation (kg N.ha^{-1})				Mean
Year	Bacterisation	0	80	120	150	
		Protein contents in wheat grain (%)				
		AC interaction				A
2010		14.575 ^{c}	14.782	15.132**	15.362**	14.962
2011		13.417 ^{c}	14.368**	14.748**	15.485**	14.505
2012		13.805 ^{c}	14.827**	15.390**	16.255**	15.069
		BC interaction				B
	With (B+)	14.621c**	15.127**	15.596**	15.889**	15.308**
	Without (B–)	13.243 ^{c}	14.191**	14.584**	15.512**	14.383 ^{c}
Effects of factor C		13.932 ^{c}	14.659**	15.090**	15.701**	–

	2010		2011		2012	
	B+	B–	B+	B–	B+	B–
AB interaction	15.263*	14.662 ^{c}	14.992**	14.018 ^{c}	15.669**	14.469 ^{c}
	Statistical analysis (LSD–values in levels 5% and 1%)					
	A	B	C	AB	AC	BC
LSD 5%	0.2136	0.2091 ^{t}	0.2792	0.4837	0.2845	0.3285
LSD 1%	0.3541	0.2811 ^{t}	0.3826	0.6627	–	0.4452

Source: research author

Based on these results we can say that the application of microbiological preparations with effective groups of microorganisms as a supplement or replacement of mineral fertilizers is very important in terms of how environmental protection and the production of organic, healthy food. The results obtained were correlated with many studies (Tanacs et al, 2005).

Conclusion

Application of microbiological preparation as a replacement mineral fertilizers is very useful in terms of economic viability and environmental importance of conservation land in soybean production. Therefore, this measure should be accepted as mandatory.

Based on these results it can be concluded that the application of such a composition in the production of major field crops in Serbia may be replaced by a quantity of mineral nitrogen.

In production of maize can be achieved by using stable yields of these preparations 80kg.ha^{-1}. In the production of wheat using which the mixture and 120 kg.ha^{-1} can be achieved by stable yield and a high level of protein content 3.15% which is the level of significance of $p < 0.01$ in relation to the variant without bacterization.

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