EFFECT OF CYANOBACTERIA (CYANOPHYTA) ON THE PROPERTIES OF DIFFERENT SOIL TYPES IN THE VOJVODINA PROVINCE

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Jovica Vasin, Vladimir Hadžić, Mitar Govedarica, Oliver Fojkar (2001.): *Uticaj Cijanobakterija (Cyanophyta) na svojstva različitih tipova zemljišta Vojvodine.* – X Kongres Jugoslovenskog društva za proučavanje zemljišta, Beograd.

U cilju istraživanja uticaja cijanobakterija na promene svojstava različitih tipova zemljišta Vojvodine. Uzorci ispitivanih genetičkih horizonata i slojeva zemljišta su inokulisani inokulumom koji je predstavljao združenu kulturu cijanobakterija. Ogled je postavljen u stakleniku u dva tretmana (inokulisano cijanobakterijama i kontrola), u četiri ponavljanja.

Na osnovu rezultata ogleda može se zaključiti da uticaj cijanobakterija na vodno - fižička i većinu osnovnih hemijskih osobina zemljišta nije bio izražen. Zabeleženo je povećanje sadržaja mineralnog azota u svim genetičkim horizontima i slojevima ispitivanih zemljišta inokulisanog tretmana u odnosu na kontrolni. Inokulacija zemljišta cijanobakterijama je kod nekih genetičkih horizonata uticalo na statistički značajno smanjenje vrednosti električne provodljivosti u saturisanom vodnom ekstraktu (Amo,p podhorizonta černozema i Aoh,na/E horizonta solonjeca) i sadržaja Na^{+} jona vodnog ekstrakta (Aoh,na/E horizonta solonjeca).

Ključne reči: svojstva zemljišta, černozem, humoglej, distrični kambisol, fluvisol, arenosol, solončak, solonjec, cijanobakterije

INTRODUCTION

Cyanobacteria (Cyanophyte) play an important role in the soil. They enrich it in nitrogen and organic substances, produce biologically active substances, lower high soil pH, reduce the levels of sodium and total salts, favorably affect soil structure, increase the content of available phosphorus, and interact with other microorganisms and plants.

Cyanobacteria are traditionally used as a microbiological fertilizer in rice paddies in tropical and subtropical regions (India, Indochina, Inodnesia, the Fillipines). Their applicability is presently being examined for less moist soils in temperate regions. Several preparations have been developed. The one that is geographically nearest to us is ”Agrovita” (Draganov, 1979), a Bulgarian preparation that comprises cyanobacteria, bacteria, enzymes and microelements.

The biological approach to the problem of soil desalinization by means of cyanobacteria was addressed in the early 1950's. An indigenous population of nitrogen-fixing cyanobacteria was used to amend saline-alkaline soils, the so-called "usars", which typically occur in northern India (Singh, 1950). Claims were made that cyanobacteria are capable of intracellular absorption, accumulation and irreversible immobilization of Na^+ ions, resulting in soil salinity reduction. Simultaneous increase in carbon and nitrogen contents was suggested as an added advantage of this soil amendment strategy (Singh, 1961). The effect of application of cyanobacteria on soil properties is equivalent to gypsum application (Kaushik i Venkataraman, 1982). Their combined application brings synergistic effects.

Kaushik and Krishna Murti (1981) reported that application of algae reduced active soil acidity. Subhashini and Kaushik (1981) attributed the lowering of soil pH (determined in H_2O) to the reduction of the content of adsorbed sodium caused by algal activity.

Electroconductivity (EC), as a measure of content of water soluble salts in soil, exhibited a considerable reduction after the application of cyanobacteria (Kaushik and Krishna Murti, 1981, Kaushik and Venkataraman, 1982).

Polysaccharides are directly responsible for soil aggregation (Cheshire et al., 1983), although Tisdall and Oades (1982) maintain a standpoint that polysaccharides are only ephemeral, short-lived glues. The role of polysaccharides in maintaining a lasting stability of soil aggregates may be due to their microbiological mineralization and the formation of recalcitrant aliphatic and polyphenolic products of degradation (Piccolo and Mbagwu, 1989).

Falchini et al. (1996) studied the effect of *Nostoc* strains on the structure and stability of a clay soil. A clay originating from Pliocene marine sediments was used in this experiment. Cyanobacterial exopolysaccharides tended to improve clay structure, as interaction occurred between exopolysaccharides and fine particles of clay.

Subhashini and Kaushik (1984) concluded that the application of cyanobacteria did not affect the content of total phosphorus in the soil, while the content of available phosphorus increased. Cyanobacteria are known for accumulation of phosphates and polyphosphates, which become available on autolysis (Kaushik, 1989).

Singh (1961) attributed some 80 kg N/ha to algal fixation in a corn crop grown in the climatic conditions of Uttar Pradesh (India). In soils of temeparate regions, cyanobacteria may fix annually over 20 kg N/ha (Day et al., 1975). In soils having the pH value of 7.0 and favorable lighting and moisture conditions, cyanobacterial biomass contains 450 kg of organic C/ha and 60 kg N/ha (Rao and Burns, 1990).

Kaushik (1989) reported significant increases in carbon (by 18.7 %) and nitrogen (by 17.9 %) in potted soil, without the presence of plants.

It is assumed that the treatment with cyanobacteria (*Nostoc sp*. and *Anabaena sp*.) may improve the water-physical, chemical and biological properties of the examined soil types of the Vojvodina Province and their generic horizons.

MATERIAL AND METHOD

Soil types needed for the experiment were sampled in the following locations: chernozem – Rimski Šančevi, humogley - Bečej, distric cambisol - Zmajevo, fluvisol - Kać, arenosol - Horgoš, solonchak – Horgoš and solonetz - Kumane. Disturbed soil samples were taken from the horizons in the zone of active rhizosphere.

The experiment was conducted in Mitscherlich pots in a greenhouse. It included two treatments, one with cyanobacteria, one without them (control). Each experiment unit (soil horizon) was replicated four times.

The inoculum used in the experiment was a mixed culture of nitrogen-fixing cyanobacteria that included *Nostoc* sp., strain 310 and *Anabaena* sp., strain 313.

The cyanobacteria-treated Mitscherlich pots each received 150 ml of suspension of bacteria and nutritive medium. The control pots received 150 ml of nutritive medium (nitrogen-free mineral medium BG-11).

Winter wheat seeds, cv Evropa 90, were subsequently placed in the pots.

After the end of growing season, the potted soil was analyzed by methods officially accepted by YSSS (1966, 1997).

The obtained data were processed by the analysis of variance for one-factorial trial in four replications. The effect of cyanobacteria on mineral nitrogen content in the soil was not statistically processed due to methodological reasons. Since the method of Scharpf and Wehrmann requires large soil samples, average samples had to be made by mixing soil from four Mitscherlich pots.

RESULTS AND DISCUSSION

Graph 1 shows the effect of cyanobacteria on the stability of soil structural aggregates.

Graph 1 – Effect of cyanobacteria on the stability of soil structural aggregates

There were no statistically significant differences between the treatments and the control in the values of the soil structural microaggregates stability index.

These results are not in agreement with the results of previous studies (Rouchudhury et al., 1979; Venkataraman, 1982; Cheshire et al., 1983) which maintained that cyanobacterial filaments exert pressure on soil particles which, together with the release of exopolysaccharides and lipids, stabilize soil aggregates by binding them into microaggregates. The absence of bacterial action in our study may be due to poorer conditions (temperature and humidity) compared with those provided in the above studies. It is assumed that successive soil inoculation with cyanobacteria through several vegetations of spring crops would produce better results.

Graph 2 – Effect of cyanobacteria on soil reaction (pH) in H_2O

With the exception of the humus-accumulating horizon of the solonchak soil, there were no statistically significant differences between the treatments and the control in the effect on nitrogen-fixing cyanobacteria on soil reaction in H_2O.

These results are in agreement with those of Kaushik (1985) and Kaushik and Subhashini (1985) who reported that nitrogen-fixing cyanobacteria did not reduce the acidity of alkaline soils unless their application was combined with drainage practices. Again it should be mentioned that the above studies provided much better conditions for bacterial development (higher temperature and humidity) than it was the case in our study.

Graph 3 – Effect of cyanobacteria on humus content in the soil

Graph 3 shows that there existed a high variability in the average values for humus content among the generic soil horizons. There were no statistically significant differences between the treatments and the control.

Graph 4 – Effect of cyanobacteria on mineral nitrogen content in the soil

Graph 4 shows that the contents of mineral nitrogen were increased in all treated soil horizons as compared with the control. These increases are attributed to atmospheric nitrogen fixation by cyanobacteria.

Graph 5 – Effect of cyanobacteria on the content of available phosphorus in the soil

Highly significant differences in the content of available phosphorus between the treatments and the control were found in the Amo chernozem horizon and the Aa,vt,p humogley subhorizon. No statistically significant differences occurred in the other horizons although there existed an evident trend of increase in the content of available phosphorus in the soil.

Graph 6 – Effect of cyanobacteria on electric conductivity in saturated water extract (ECe 25ºC)

The electric conductivity in saturated water extract of the analyzed soil samples ranged from 0.488 mS/cm in arenosol to 3.402 mS/cm in the C horizon of the solonchak soil (Graph 6). The differences in the values of electric conductivity in saturated water extract (obrtained by soil paste filtering) between the treatments and the control were highly significant for the Amo,p subhorizon of the chernozem soil and significant for the Aoh,na/E horizon of the solonetz soil.

Graph 7 – Effect of cyanobacteria on the content of Na^+ ions in saturated water extract and adsorptive complex

Graph 7 shows the effect of nitrogen-fixing cyanobacteria on only those soil horizons which had increased values of Na^+ content in water extract and adsorbed Na^+. Considering the content of adsorbed Na^+ in the analyzed horizons, it is evident that in this experiment the nitrogen-fixing cyanobacteria did not take up adsorbed Na^+, i.e., they did not contribute to its decrease in the soil.

CONCLUSION

Based on the results of this study, it was concuded that the effect of nitrogen-fixing cyanobacteria (*Nostoc* sp. strain 310 and *Anabaena* sp. strain 313) on the stability of microaggregates of different soil types of the Vojvodina Province was not pronounced.

Of the chemical soil properties examined, the content of mineral nitrogen was most responsive to the influence of cyanobacteria. Its increase was due to the fixation of atmospheric nitrogen taking place in the course of wheat vegetative period. Increases occurred in all soil layers and horizons. Differences in the rate of increase among the treatments corresponded to the number of the nitrogen-fixing cyanobacteria present.

The effect of application of nitrogen-fixing cyanobacteria on the basic chemical soil properties was negligible. An exception occurred in the case of the content of available phosphorus which increased on inoculation in the Amo chernozem horizon and the Aa,vt,p humogley subhorizon.

The action of nitrogen-fixing cyanobacteria reduced the values of electric conductivity in saturated water extract (in the Amo,p chernozem subhorizon and the Aoh,na/E solonetz horizon) and Na^+ content in water extract (in the Aoh,na/E solonetz horizon).

The observed low effectiveness of nitrogen-fixing cyanobacteria was due to unfavorable environmental conditions. A long period of low temperatures occurred in the course of the wheat vegetative period. Furthermore, the soil moisture level scheduled according to wheat requirements cannot be compared with the situations described in foreign literature (rice paddies of India and Indochina). It is believed that successive soil inoculation with cyanobacteria through several vegetations of spring crops would produce better results.

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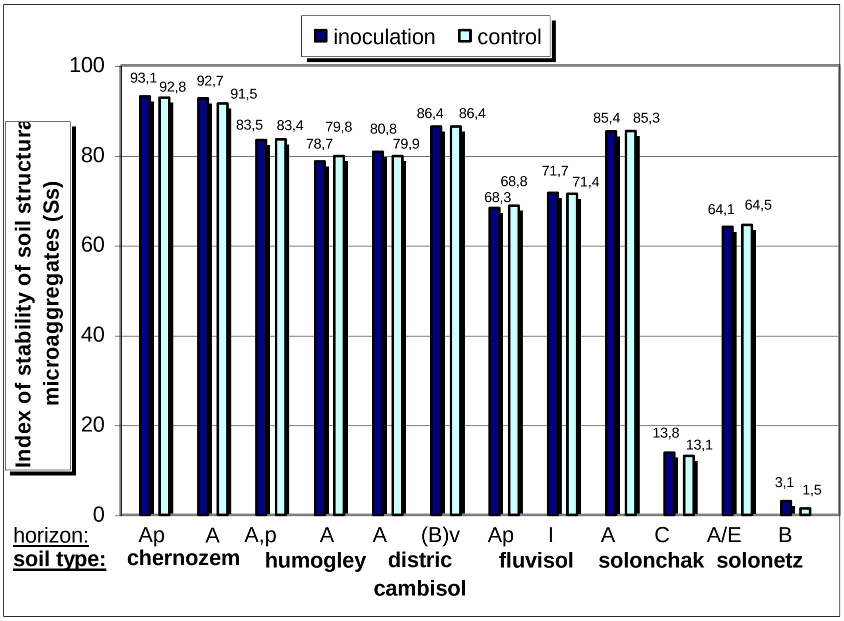
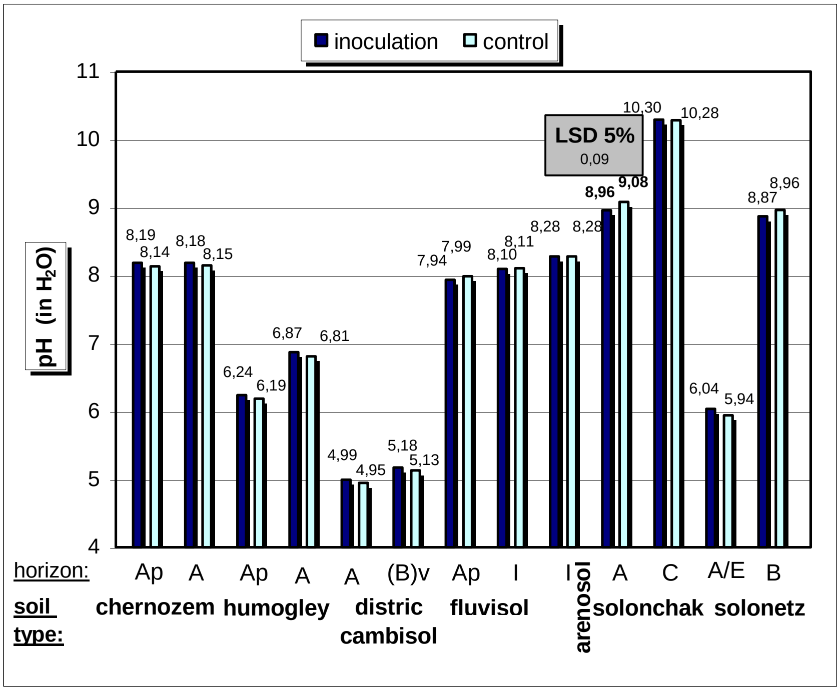


Graph 1



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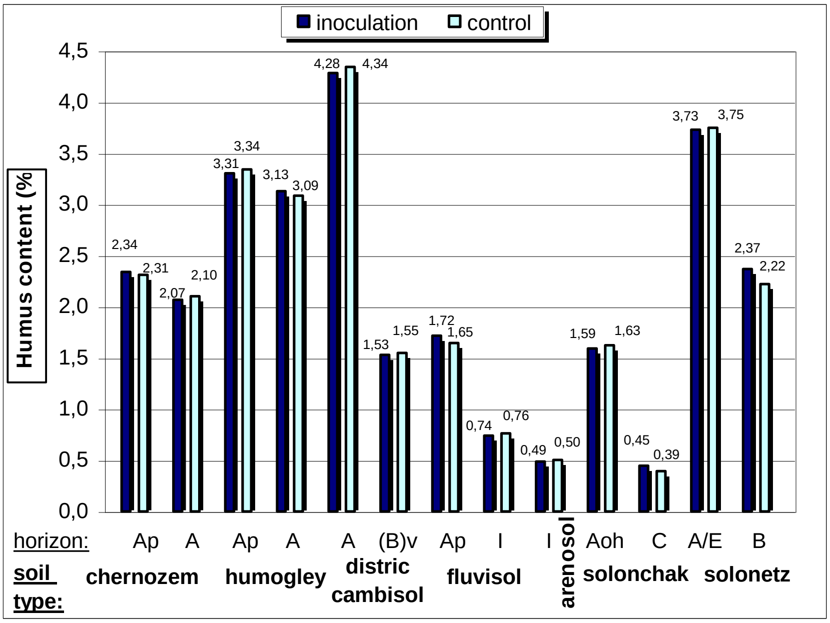

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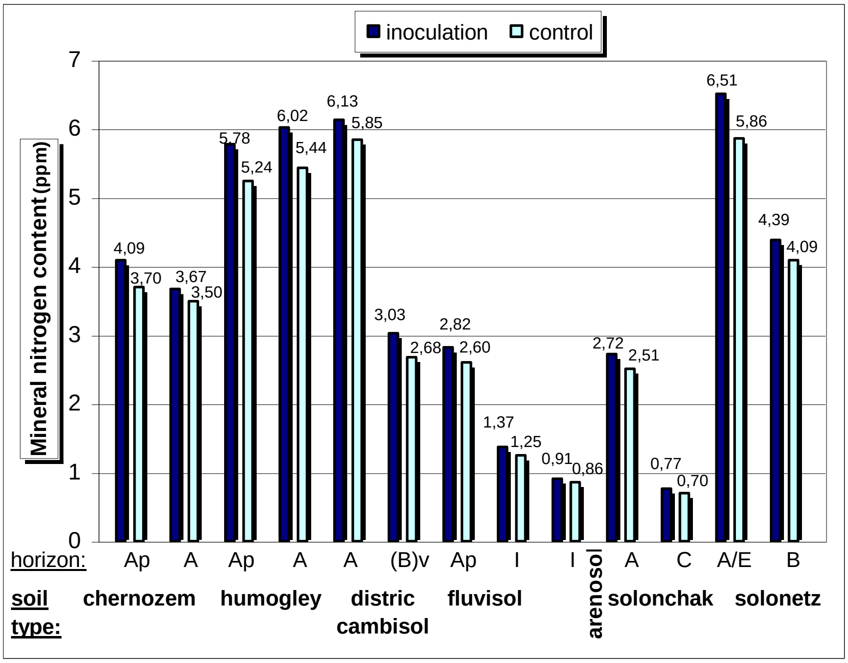

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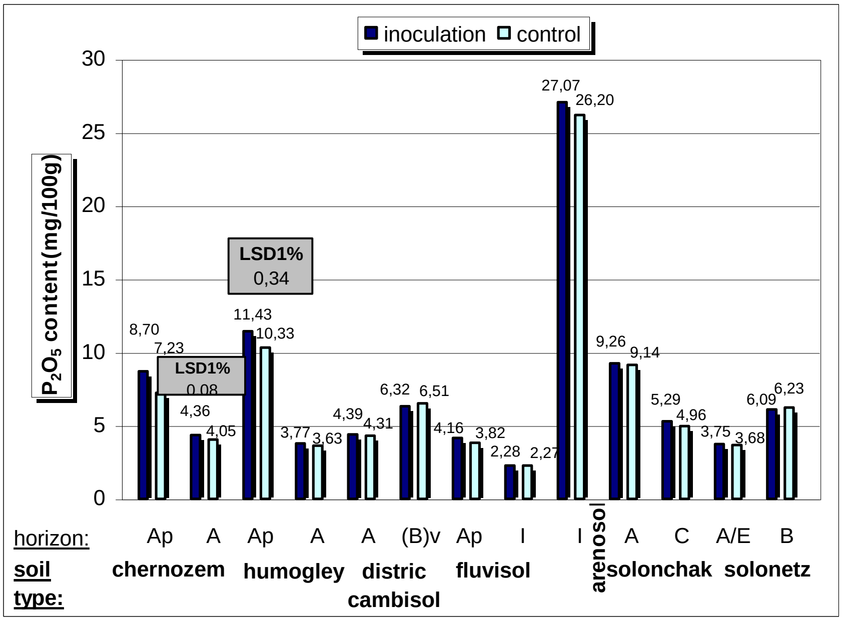
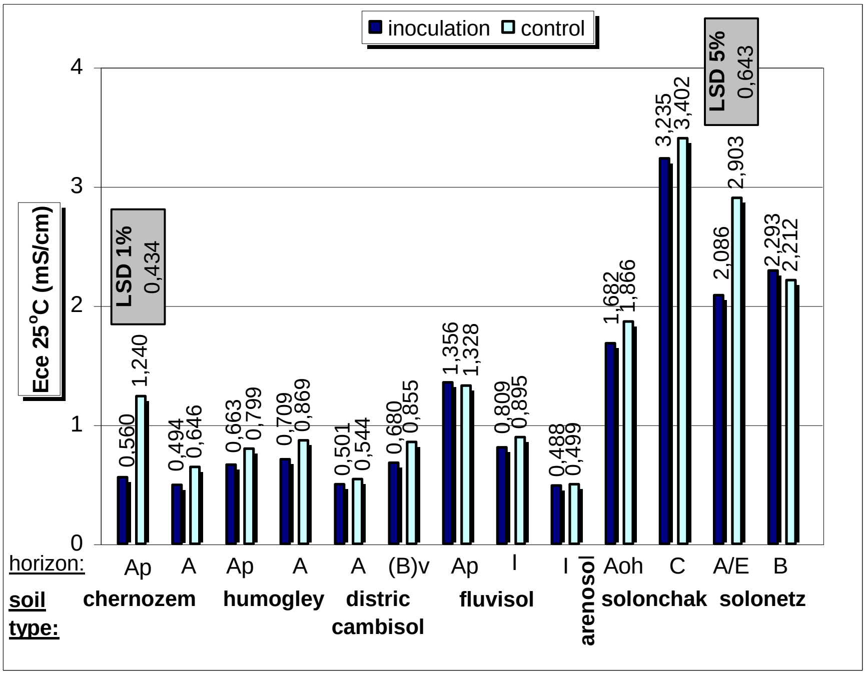
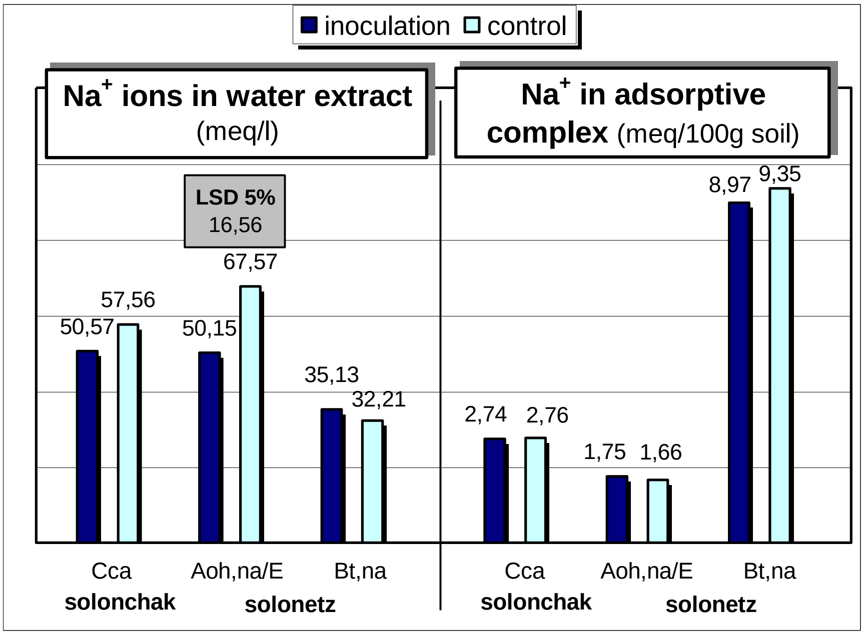


Graph 5



Graph 6


inoculation
control
Na+ ions in water extract
(meq/l)
LSD 5%
16,56
57,56
50,57
50,15
67,57
35,13
32,21
Cca
Aoh,na/E
Bt,na
solonchak
solonetz
Na+ in adsorptive
complex (meq/100g soil)
2,74
2,76
1,75
1,66
8,97
9,35
Cca
Aoh,na/E
Bt,na
solonchak
solonetz

Graph 7