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# THE USE OF AZOTOBACTER IN MAIZE PRODUCTION: THE EFFECT ON MICROBIOLOGICAL ACTIVITY OF SOIL, EARLY PLANT GROWTH AND GRAIN YIELD*

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*SUMMARY. The experiment focused on examining the effect of a mixture of azotobacter strains on the early growth of maize, grain yield and microbiological activity in rhizospheric soil of three maize hybrids: Tisa, NS5010 and NS444 ultra. Before seeding, the mixture of azotobacter strains was applied to one half of the experimental plot.The use of azotobacter led to an increase in the number of microorganisms. The mixture of azotobacter strains stimulated the early growth of maize to a great extent. With Tisa hybrid, the plants were up to 5 cm higher than the control plants and with NS444 ultra, the plants were up to 19,63 cm taller than the control plants. The grain yield in the variants with azotobacter increased with all three hybrids. The highest increase in yield was in NS5010 hybrid: 641 kg ha$^{-1}$, in Tisa 403 kg ha$^{-1}$ and in NS444 ultra, the grain yield increased by 396 kg ha$^{-1}$.*

***Key words**: azotobacter, growth of maize, microorganisms, grain yield.*

## INTRODUCTION

Thanks to microorganisms in soil, synthesis and transformation of organic matter take place all the time. In this way a part of necesarry nutrients for plants is supplied. In the nutrition of all crops, including maize, nitrogen has an important role. Many investigations have shown that certain amounts of mineral nitrogen can be replaced when nitrogen-fixing bacteria are used (Okon and Itzigson,1995; Govedarica et al., 2001). In the production of field crops and vegetables, azotobacter is the one which is most frequently applied (Jarak et al., 2008; Mrkovački et al., 2006).

The aim of the experiment was to examine the effect of azotobacter on the microbiological activity of rhizospheric soil, early growth of maize and grain yield.

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## MATERIAL AND METHODS

Three maize hybrids were used in the experiment: Tisa (FAO 700), NS 5010 (FAO 500) and NS 444 ultra (FAO 400, selection of the Institute of Field and Vegetable Crops, Novi Sad). In autumn, before primary soil treatment, 300kg/ha of the mineral fertilizer NPK (15:15:15) was applied. The type of soil was chernozem soil, in the locality of Futog.

Before seeding, a mixture of azotobacter strains was introduced into one half of the experimental plot. One litre of the inoculum with the cell density of $10^9$ in 1ml was dilluted in 300 l of water and sprayed into the soil. After this, the upper layer of soil was additionally prepared for planting with a cultivator so that microorganisms would incorporate into the soil as well as possible. In the growth phase of 6-8 leaves, the length of the plant was measured and microbiological analysis of the rhizospheric soil conducted. The total number of microorganisms was determined by Poshon method, the number of fungi was measured on potato-dextrose medium and the number of azotobacter was determined by Fjodorov method (Jarak and Đurić, 2006). After harvesting, the grain yield (with 14% grain humidity) was measured in t/ha. The data were processed by analysis of variance and the significance was expressed by LSD test.

## RESULTS AND DISCUSSION

The hybrids which were examined in this experiment have a high genetic fertility potential and are frequently used in production. In order for the hybrids to realize this potential, it is necessary to provide them with adequate nutrition during the growth period. One part of nutrients is created during microbiological processes in soil. The activity of microorganisms depends on soil characteristics, plants, agrotechnical measures etc.

These investigations were conducted in chernozem soil which has optimum conditions for microbiological processes (Belić et al, 2005; Đurić et al., 2008). Microbiological processes can additionally be stimulated by introducing biofertilizers. These microorganisms reproduce in soil and with their enzymatic activity raise and keep the appropriate level of organic matter in soil (Hajnal et al., 2005; Jarak et al., 2009). In this experiment, in the growth phase of 6-8 leaves, the number of microorganisms was larger when the mixture of *Azotobacter chroococcum* strains was applied than in the control (Table 1).

Table 1. The effect of Azotobacter chroococcum (AZ) on the total number of microorganisms (TN), number of fungi (F) and number of azotobacter (AZ) in rhizospheric soil of maize
*Tabela 1. Uticaj Azotobacter chroococcum (AZ) na ukupan broj mikroorganizama (TN), broj gljiva (F) I broj azotobaktera (AZ) u rizosfernom zemljištu pod kukuruzom*

| Hybrids *Hibridi* (A) | TN ($10^6$ $g^{-1}$ apsolutly dry soil) *($10^6$ $g^{-1}$apsolutno suvog zemljišta)* | | F ($10^4$ $g^{-1}$ apsolutly dry soil) *($10^4$ $g^{-1}$apsolutno suvog zemljišta)* | | AZ *($10^2$ $g^{-1}$ apsolutly dry soil) ($10^2$ $g^{-1}$apsolutno suvog zemljišta)* | |
|---|---|---|---|---|---|---|
| | Control *Kontrola* (B) | AZ (B) | Control *Kontrola* (B) | AZ (B) | Control *Kontrola* (B) | AZ (B) |
| NS 5010 | 5.3 | 252.5 | 2.5 | 2.9 | 29.5 | 44.7 |
| NS 444 ultra | 11.9 | 85.5 | 1.8 | 3.0 | 40.5 | 79.7 |
| Tisa | 9.3 | 23.4 | 1.4 | 2.2 | 42.2 | 60.1 |
| *Average* Prosek | 8.86 | 120.52 | 1.96 | 2.70 | 37.4 | 61.5 |
| A | LSD 0.05 0.01 | | LSD 0.05 0.01 | | LSD 0.05 0.01 | |
| B | 26.12 | 45.50 | 1.53 | 2.17 | 7.17 | 10.20 |
| AxB | 31.99 | 37.15 | 1.25 | 1.78 | 5.85 | 8.34 |
| | 45.24 | 64.35 | 2.16 | 3.07 | 10.14 | 14.43 |

The number of the examined microorganisms was also dependant upon the maize hybrid (Table 1). Namely, plants secrete through the root different organic and mineral substances which are used by rhizospheric microorganisms for nutrition. Even though the plant is the same, the number of microorganisms in rhizospheric soil also depends on hybrids and varieties within the same sort (Walker et al., 2003). A large number of rhizospheric microorganisms, including azotobacter, produce growth substances such as auxins, gibberellins etc.

The use of these microorganisms stimulates the early growth and development of a plant (Jarak et al., 2007; Udovički and Jarak, 2005). In this experiment, the mixture of *Azotobacter chroococcum* strains stimulated the early growth of maize to a great extent. With Tisa hybrid, the plants were up to 5 cm higher than the control plants. With NS444 ultra, the plants were up to 19.63 cm and with NS 5010 were up 16. 33 cm higher than the control plants ( P>0.01) (Table 2).

Table 2. The effect of Azotobacter chroococcum on the hight of plant, phase 6-8 leaves
*Tabela 2. Uticaj Azotobacter chroococcum na visinu biljke u fazi 6-8 listova*

| Hybrids *Hibridi* (A) | Hight of plant (cm) / *Visina biljke (cm)* | | |
|---|---|---|---|
| | Control *Kontrola* (B) | *A.chroococcum* (B) | Difference between treatment and control *Razlika između tretmana i kontrole* |
| NS 5010 | 51.67 | 68.00 | 16.33 |
| NS 444 ultra | 57.67 | 77.33 | 19.63 |
| Tisa | 51.83 | 57.00 | 5.17 |
| Average / Prosek | 53,72 | 67,44 | 13,69 |
| LSD A B AxB<br>0.05 4.53 3.70 6.41<br>0.01 6.44 5.26 9.11 | | | |

In comparison with the control, there was a statistically significant increase of the grain yield in all three hybrids (P>0.05) when azotobacter was used. With NS5010 hybrid, the increase was statistically highly significant (P>0.01). The grain yield was higher by about half a tons per hectare in comparison with the control (Table 3).

Table 3. The effect of *Azotobacter chroococcum* on the yield of seed of maize
*Tabela 3. Uticaj Azotobacter chroococcum na prinos zrna kukuruza*

| Hybrids / *Hibridi* (A) | Yield (t ha$^{-1}$) / *Prinos (t ha$^{-1}$)* | | |
|---|---|---|---|
| | *Control* - Kontrola (B) | *A. chroococcum* (B) | Difference between treatment and control *Razlika između tretmana i kontrole* |
| Tisa | 9.496 | 9.889 | 0.403 |
| NS 5010 | 9.008 | 9.649 | 0.641 |
| NS 444 ultra | 9.898 | 10.294 | 0.396 |
| Average / *Prosek* | 9.467 | 9.959 | 0.492 |
| LSD A B<br>0.05 0.484 0.395<br>0.01 0.669 0.546 | | | |

According to results of Govedarica et al. (2004), with introduction of azotobacter, biological activity in soil increases, and yield of maize depends on hybrids and strains azotobacter.

The increase in yield can be due to the influence of *Azotobacter chroococcum* which fixes up to 90 kg N ha$^{-1}$ a year which increases the nitrogen pool and biological activity of soil (Hajnal et al., 2004; Jeličić et al., 2008).

## CONCLUSION

The value of the investigated parameters was dependant on inoculation, hybrids and their interaction.

The use of *Azotobacter chroococcum* led to an increase in the number of microorganisms.

*Azotobacter chroococcum* stimulated the early plant growth. The increase in height in the inoculated variants ranged from 5 cm in Tisa hybrid to 20 cm in NS444 ultra hybrid. The use of *Azotobacter chroococcum* led to a higher grain yield in all three maize hybrids. The highest increase in yield was in NS5010 hybrid: 641 kg ha$^{-1}$, in Tisa 403 kg ha$^{-1}$ and in NS444 ultra, the grain yield increased by 396 kg ha$^{-1}$.

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# PRIMENA AZOTOBAKTERA U PROIZVODNJI KUKURUZA: UTICAJ NA MIKROBIOLOŠKU AKTIVNOST U ZEMLJIŠTU, POČETNI RAST BILJKE I PRINOS ZRNA

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## Izvod

Ispitivan je uticaj smeše sojeva azotobaktera na početni porast biljke, prinos zrna i mikrobiološku aktivnost u rizosfernom zemljištu kod tri hirida kukuruza: Tisa, NS 5010 i NS 444 ultra. Pre setve na polovini ogledne površine uneta je smeša sojeva *Azotobacter chroococcum* Jedan litar inokuluma gustine ćelija $10^9$ u ml, razblažen je u 300 l vode i prskalicom je unet u zemljište. Nakon toga je površinski sloj zemljišta dodatno pripremljen frezom kako bi se uneti mikroorganimi što bolje izmešali sa zemljištem. U fazi porasta 6-8 listova izmerena je dužina biljke i urađena mikrobiološka analiza rizosfernog zemljišta i to ukupan broj mikroorganizama, broj gljiva i broj azotobaktera. Nakon skidanja useva izračunat je prinos zrna u t/ha sa 14 % vlage. Visina biljaka u fazi 5-7 listova na inokulisanim varijantama bila je povećana od 5 d0 20 cm. Prinos zrna kod sva tri hibrida kukuruza bio je povećan na inokulisanim varijantama. Povećanje prinosa je bilo statistički značajno za P>0.05 i kod hibrida NS 5010 bilo je 641 kg $ha^{-1}$, kod hibrida Tisa 403 kg $ha^{-1}$ i kod hibrida NS 444 396 kg $ha^{-1}$.

**Ključne reči:** kukuruz, azotobakter, mikroorganizmi, visina biljke, prinos.

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