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The Effect of Diazotrophs on Yield and Yield Components of Spring Wheat

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Abstract: The effectiveness of eight strains of *Azotobacter chroococcum* and of one strain of *Azospirilum lipoferum* and *Beijerinckia Derx* each was studied in two varieties of wheat Nevesinjska and Venera grown in vegetation house on the soil of the carbonate chernozem type. The efficiency of diazotrophs was found to depend on their type, wheat variety and the properties studied. The best efficiency was obtained on the strains *Azotobacter chroococcum*. The efficiency of diazotrophs was the best in Nevesinjska, and somewhat weaker in Venera. The examined kinds of diazotrophs mainly led to an increase in plant height, number of nodes, spike length, number of fertile and sterile spikelets per spike, productive tillering, absolute mass of 1000 kernel weight, grain number per spike and per plant and grain yield per spike and per plant, as well.

Key words: diazotrophs, wheat, nitrogen, yield

Introduction

One of the most important problems in wheat production is to provide for sufficient quantities of nitrogen ensuring high yield. Beside organic, mineral fertilisers are also used in wheat production today. Nitrogen mineral fertilisers are costly, of poor quality and environmental pollutants. In addition, 10-30%

mineral nitrogen is either lost during denitrifying process or leached in groundwaters. Different kinds of diazotrophs and nitrogen fixers, which, by means of nitrogenous enzymes, can fix 30-60, and, by some authors, even up to 150 kilogrammes of atmospheric nitrogen per hectare live in soil (Doberainer et al., 1972; Misustin, 1982; Umarov, 1982; Govedarica et al., 1994; Kozemjakov and Tihonovic, 1998). Introducing of the highly effective species and strains of diazotrophs obtained through selection of particular quantity of the mineral nitrogen may be replaced with biological nitrogen, as its more suitable form for the plants. Diazotrophs have the ability to swiftly colonize on the plant root or to enter into it directly delivering overall fixed nitrogen to the plants in its most suitable form. On our planet, some 170-190 million tonnes of atmospheric nitrogen are fixed in all the ecosystems by means of diazotrophs (Babeva and Zenova, 1989).

Apart from nitrogen fixation, diazotrophs also synthesize physiologically active matter, such as: auxin, gibberellin, cytokinin and vitamins. This helps enhance respiration and photosynthesis process, water and mineral matter intake, plant resistance to phytopathogenic microorganisms and stressful circumstances. Diazotrophs also produce mucous matter allowing microaggregates and macroaggregates to stick together and thus improve soil structure. Also, diazotrophs enhance both, number and biochemical activity of other microorganisms and thus raise soil fertility. They are able to absorb and accumulate a range of heavy metals, radio-active matter and pesticides in their cells, thereby excluding them from the process of cycling.

Materials and method

Eight strains of Azotobacter chroococcum and one strain of *Azospirillum lipoferum* and *Beijerinckia Derx* each were picked out for current sudies. Bacteria strains were propagated on the appropriately selected nutritional stocks. Two varieties of the spring wheat, Venera and Nevesinjska, grown in Mitscherlich's dishes on the carbonate chernozem soil, were used for the experiment. The soil was mixed with river sand in the ratio 4:1. The experimental treatments were, as follows: 1. control without addition of mineral nitrogen; 2. control with the addition of 0.5 g NH_4NO_3 per dish versus 62.8 kg N/ha; 3. control with the addition of 1.0 g NH_4NO_3 per dish versus 125.6 kg N/ha; 4. control with the addition of 1.5 g NH_4NO_3 per dish versus 188.4 kg N/ha; 5. *Azotobacter chroococcum* strain 2; 6. *Azotobacter chrocooccum* strain 3; 7. *Azotobacter chroococcum* strain 10; 8. *Azotobacter chroococcum* strain 6; 9. *Azotobacter chroococcum* strain 20; 10. *Azotobacter chroococcum* strain 76; 11. *Azotobacter chroococcum*, strain 84; 12. *Azotobacter chroococcum*, strain 86; 13. *Beijerinckia Derx*, strain 2; 14. *Azospirillum lipoferum*, strain 107. Wheat plants were grown under temperature coinditions of the vegetation house. Prior to seeding, wheat seeds were and control treatments were not inoculated with diazotrophs. Soil humidity was maintained at the optimal level (60-80% retention water capacity). At the end of wheat vegetation, harvest was performed by cutting off the plants just above the soil surface. The following determinations were made: plant height, node number,

spike length, he number of fertile and sterile spikelets per spike, productive tillering, the absolute mass of 1000 kernels per spike, kernel number per plant, grain yield per spike and per plant.

Results and discussion

The application of diazotrophs was found to increase spring wheat yield with decrease in mineral nitrogen amounts.

The efficiency of diazotrophs was found to depend on their type, wheat variety and on the traits studied. In both varieties, seed inoculation of wheat with diazotrophs led to increase in plant height, node number and spike length (tab.1.).

Tab.1. The Effect of Diazotrophs on Plant Height, Node Number and Spike Length

Treatment	Plant Height		Node Number		Spike length	
	Nevesinjka	Venera	Nevesinjka	Venera	Nevesinjka	Venera
Control without min. nitrogen	55.20	51.00	3.00	3.00	5.20	4.66
Control with 0.5 g NH_4NO_3	55.80	51.20	3.00	3.00	5.35	4.55
Control with 1.0 g NH_4NO_3	56.00	51.80	3.00	3.00	5.25	4.82
Control with 1.5 g NH_4NO_3	59.30	53.30	3.00	3.00	5.28	5.61
A. chroococcum strain 2	60.83	54.03	3.10	3.00	5.70	4.32
A. chroococcum strain 3	61.32	55.70	3.06	3.00	5.66	5.03
A. chroococcum strain 10	59.30	53.80	3.00	3.31	5.56	4.40
A. chroococcum strain 16	58.97	54.90	3.34	3.20	5.50	4.83
A. chroococcum strain 20	58.91	53.60	3.03	3.00	5.62	4.63
A. chroococcum strain 76	52.80	57.10	3.00	3.00	5.40	4.53
A. chroococcum strain 84	58.70	54.62	3.00	3.00	5.30	4.63
A. chroococcum strain 86	59.50	53.09	3.06	3.03	5.43	4.83
Beijerinckia Derx strain 2	57.70	52.20	3.06	3.00	5.33	4.84
Azospirilum lipoferum strain 107	55.40	51.70	2.82	2.90	5.40	5.00

Thus, *Azotobacter chroococcum*, strain 3 exerted the highest increase. Diazotrophs also led to a higher number of fertile and sterile spikelets per spike (tab. 2). Under the effect of the investigated diazotrophs, the absolute mass of 1000 seeds, the number of seeds per spike and the yield of seed per spike were

increased in both wheat varieties (tab. 3). All the traits were found to increase best with *Azotobacter chroococcum*, strain 3. The diazotrophs indicated the best efficiency in the variety Nevesinjska. High nitrogen fixing activity of diazotrophs caused greater fixation of the atmospheric nitrogen which was delivered to wheat plant for use, hence a higher yield. Similar results were obtained by other authors (Doberainer, 1978; Feodorova, 1990; Govedarica et al., 1994, 1996; Jarak et al., 1997, 1998; Kozemjakov and Tihonovic, 1998). Many authors think that diazotrophs selelection should be performed at the level of plant genotype in order to choose the most efficient species and strains (Umarov, 1983; Zavjagincev, 1985; Vasjuk, 1987; Govedarica et al., 1990, 1996, 1997, 1998). This was proved in our studies so that *Azotobacter chroococcum* strain 3 was the most efficient in the variety Nevesinjska and *Azotobacter chroococcum* strain 76 in Venera.

Tab.2. The Effect of Diazotrophs on the Number of Fertile and Sterile Spikelets per Spike

Treatment	Number of fertile spikelets per spike		Number of sterile spikelets per spike	
	Nevesinjka	Venera	Nevesinjka	Venera
Control without min. nitrogen	16.40	16.49	3.30	2.68
Control with 0.5 g NH_4NO_3	16.50	16.11	4.48	2.70
Control with 1.0 g NH_4NO_3	16.70	16.50	4.83	2.60
Control with 1.5 g NH_4NO_3	16.70	16.14	4.20	2.46
A. chroococcum strain 2	18.26	14.91	2.88	2.96
A. chroococcum strain 3	18.53	15.65	2.90	3.24
A. chroococcum strain 10	17.96	15.21	3.66	3.20
A. chroococcum strain 16	17.62	15.75	2.96	3.83
A. chroococcum strain 20	18.13	15.10	2.63	3.08
A. chroococcum strain 76	17.42	15.16	2.56	3.00
A. chroococcum strain 84	17.33	16.50	2.73	3.10
A. chroococcum strain 86	17.33	15.06	2.80	2.72
Beijerinckia Derx strain 2	16.03	16.38	2.93	3.16
Azospirilum lipoferum strain 107	22.83	17.50	3.52	3.41

When using diazotrophs in wheat production, biological nitrogen may, to some extent, substitute for the mineral one, and thus help produce ecologically highly valuable agricultural produce.

Tab.3. The Effect of Diazotrophs on the Absolute Mass of 1000 kernels, Grain Number per Spike and Yield per Spike

Treatment	Absolute mass 1000 kemels		Grain number per spike		Yield per spike	
	Nevesinjka	Venera	Nevesinjka	Venera	Nevesinjka	Venera
Control without min. nitrogen	31.60	31.30	16.40	16.49	0.55	0.45
Control with 0.5 g NH_4NO_3	36.00	32.00	16.50	16.11	0.67	0.53
Control with 1.0 g NH_4NO_3	36.60	33.30	16.70	16.50	0.68	0.56
Control with 1.5 g NH_4NO_3	36.30	32.60	16.70	16.14	0.65	0.68
A. chroococcum strain 2	38.80	33.30	18.26	14.91	0.60	0.47
A. chroococcum strain 3	42.40	36.00	18.53	15.65	0.76	0.50
A. chroococcum strain 10	40.00	33.00	17.96	15.21	0.78	0.53
A. chroococcum strain 16	40.30	32.30	17.62	15.75	0.95	0.78
A. chroococcum strain 20	41.30	35.00	18.13	15.10	0.93	0.73
A. chroococcum strain 76	40.60	35.60	17.92	15.16	0.88	0.72
A. chroococcum strain 84	41.30	33.00	17.33	16.50	0.87	0.63
A. chroococcum strain 86	39.30	35.00	17.33	15.06	0.63	0.53
Beijerinckia Derx strain 2	41.30	34.00	16.03	16.38	0.59	0.59
Azospirilum lipoferum strain 107	41.00	33.20	22.08	17.50	1.01	0.82

Conclusions

The efficiency of diazotrophs was found to depend on the type of diazotrophs, wheat variety as well as on the traits under way.

The best efficiency was achieved with the strains *Azotobacter chroococcum.*

The efficiency of diazotrophs was the best in the variety Nevesinjska and somewhat poorer in Venera.

The types of diazotrophs mainly brought about an increase in plant height, followed by that in node number, spike length, fertile and sterile spikelet

number per spike, productive tillering, the absolute mass of 1000 kernels, grain number per spike and per plant and grain yield per spike and per plant, as well.

Therefore, using of diazotrophs in wheat production will increase yield sparing nitrogen mineral fertilisers. In such a way, an agricultural produce of the high ecological value will be obtained.

References

Babeva, I. P., Zenova, A. R (1989): Biologija počv. Izd. Moskovskogo univerziteta, Moskva.

Döberainer, J., Daj, J. M., Dart, P. J.(1972): Nitrogenase activity and oxygen senzitivity of the Paspalum notatum - Azotobacter paspalli association. J. Gen. Microbiol. 71, No 1, 103-106.

Döberainer, J. (1978): Influence of environmental factor on the occurence of Spirillum lipoferum in soil and roots. Ecol. Bull. No 26, 343-351.

Govedarica, M. (1990): Azotofiksatori i njihova aktivnost kod kukuruza. Doktorska disertacija, Poljoprivredni fakultet, Novi Sad.

Govedarica, M. (1992): Efektivnost azotobaktera kod nekih hibrida kukuruza. Savremena poljoprivreda, Vol. 40, Broj 6, 87-93.

Govedarica, M., Jeličić Zora, Milutinović Vera, Jarak Mirjana, Milošević Nada (1992): Ispitivanje efektivnosti azotofiksatora kod kukuruza. Zbornik Matice srpske za prirodne nauke, Sv 82, 119-122.

Govedarica, M., Jeličić Zora, Jarak Mirjana, Milošević Nada, M. Pavlović (1992): Ispitivanje efektivnosti različitih vrsta azotobaktera kod kukuruza. Zbornik radova devetog savetovanja agronoma i tehnologa. 14-16. 02., Smederevo, 44-47.

Govedarica, M., Jeličić Zora, Jarak Mirjana, Milošević Nada, M. Pavlović (1996): Diazotrofi i njihova aktivnost kod kukuruza. Zbornik radova desetog međunarodnog savetovanja agronoma i tehnologa. 13-16. 02., Aranđelovac, 153-159.

Govedarica, M., Jeličić Zora, Jarak Mirjana, Milošević Nada, M. Pavlović (1997): Mogućnosti primene biološkog azota u proizvodnji kukuruza. Zbornik radova desetog međunarodnog saveto-vanja agronoma i tehnologa. 13-16. 02., Aranđelovac, 69-77.

Govedarica, M., Jeličić Zora, Jarak Mirjana, Milošević Nada, Nada Stojnić, D. Rašković (1998): Značaj asocijativne azotofiksacije u proizvodnji kukuruza. Zbornik naučnih radova PKB "INI Agroekonomik", 4, 95-101.

Govedarica, M., Protić, R., Milošević Nada, Jarak Mirjana, Đukić, N. (1999): Mogućnost primene biološkog azota u proizvodnji pšenice. Zbornik naučnih radova PKB "INI Agroekonomik", Vol.5, br1, 55-61.

Feodorova, L. S., Pozonjakova, L., Kanevskaja, S. V. (1985): Videlenie Azospiril iz kulturnih i dokorastucih zlakov saratovskoj oblasti. Mikrobiologija, T. 54, Nauka, 684-685.

Kožemjakov, P. A., and Tihonovič. A. I. (1998):Ispolzovanie inokulantov bobovih i biopreparatov kompleksnovo dejstvija v seljskom hozjajstve. Naučno - teoretičeskij žurnal Rossijskoj akademii seljskohozajstvenih nauk. No 6, 7-10.

Kasiljnikov, N. A. (1985): Biologija otedeljnih grup aktinomicetov. Nauka, Moskva.

Jarak Mirjana, Protić, R., Govedarica, M., Milošević Nada, Đurić, N. (1997) Mikrobiološka aktivnost pod pšenicom inokulisanom diazotrofima. Zbornik naučnih radova PKB "INI Agroekonomik", Vol.3, br.1, 39-45.

Jarak , M., R. Protić, M. Govedarica, Nada Milošević, N. Urić (1998): Uticaj agrotehničkih mera na mikrobiološku aktivnost u rizosferi pšenice. Zbornik naučnih radova PKB "INI Agroekonomik", 4, 39-45.

Mišustin, E. N., Kalininskaja, T. A., Cerpakovaž, M. J. (1978): Nesimbiotičeskaja azotofiksacija v pohotvih počvah. U. KN. Problmi počvovedenia. M. s. 92-96.

Pochon, J. and Tardieux, P. (1962): Techniques d'analyse enmicrobiologie du soil. Edit. de la Tourelle, Paris.

Thalmann, A. (1968): Zur Methodik des Bestimmung der Dehydrogenase Activat in Boden Mittels Triphenyltetrazoliumhlorid (TTC). London. Forch 21, 249-258.

Umarov, M. M. (1983): Asocijativna azotofiksacija (osobenosti, produktivnost, značenje v azotnom bilanse počve). Avtoref. dokt. dis. M.: MGU, 49s.

Umarov, M. M. (1985): Asocijativna azotofiksacija problemi i perspektiva. Bjulten VNII s-h. Mikrobiologii, No 42, 9-14.

Vasjuk, F. L. (1985): Asovcijativni azotofiksatori i uslovi in efektivnovom primenenia. Bjulten VNII s-h. Mikrobiologii, No 42, 16-24.

Zavjagincev, G. D. (1985): Problemi upravlenia azotofiksatorami v rizosfere v rizoplane. Bjulten VNII s-h. Mikrobiologii, No 42, 6-9.

UTICAJ DIAZOTROFA NA PRINOS I KOMPONENTE PRINOSA JARE PŠENICE

-originalni naučni rad-

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Rezime

Diazotrofi ili azotofiksatori su mikroorganizmi koji u svojim ćelijama uz pomoć enzima nitrogenaze vrše fiksaciju atmosferskog azota kojeg potom u najpovoljnijem obliku daju biljci na korišćenje.

Cilj ovih istraživanja je bio da se ispita uticaj diazotrofa na prinos i komponente prinosa kod dve sorte jare pšenice.

Biljke pšenice sorte Nevesinjka i Venera su gajene u prirodnim temperaturnim uslovima u vegetacionoj kući na zemljištu tipa karbonatni černozem. U radu je ispitan uticaj osam sojeva *Azotobacter chrococcum* i po jedan soj *Azospirillum lipoferum* i *Beijerinckia Derx.*

Efektivnost diazotrofa je zavisila od vrste diazotrofa, sorte pšenice i svojstava koja su ispitivana. Najveća efektivnost dobijena je sa sojevima *Azotobacter chroococcum.* Diazotrofi su najveću efektivnost ispoljili kod sorte Nevesinjka a nećto slabiju kod sorte Venera. Ispitivane vrste diazotrofa su uglavnom izazvale povećanje visine biljaka, broja nodija, dužine klasova, broja fertilnih i sterilnih klasaka u klasu, produktivno bokorenje, apsolutnu masu 1000 zrna, broj zrna u klasu i po biljci, prinos zrna po klasu i biljci. Primenom diazotrofa u proizvodnji pšenice dobilo bi se povećanje prinosa uz uštedu azotnih mineralnih đubriva. Tako bi se dobio ekološki visoko vredan poljoprivredni proizvod.