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BENEFITS OF INOCULATION WITH AZOTOBACTER IN THE GROWTH AND PRODUCTION OF TOMATO AND PEPPERS

ABSTRACT: The aim of this research was to investigate the effects of *Azotobacter chroococcum* in tomato and pepper growth and production by using two types of inoculation — seed inoculation and seedling inoculation. The effect of inoculation was observed thirty days after sowing, thirty days after transplanting, and in the phase of technological maturity. The following were measured: height of the plants, dry matter of the plants and number and the weight of the fruits. Inoculation had a positive effect on these in both plants. With tomato, better results were achieved when seedlings were inoculated. With pepper, the length of the plant and the dry matter were greater with seedling inoculation, whereas the number and the weight of the fruits were greater with seed inoculation.

KEY WORDS: inoculation, azotobacter, tomato, pepper

INTRODUCTION

Azotobacter strain is a free-living nitrogen-fixer. It lives freely in soil, growing in abundance in the rhizosphere with a higher concentration of organic matter secreted by plants (Berkum and Bohlool, 1980). Sometimes azotobacter lives on the very surface of the root, making a mucous cover and thus creating a stronger bond with the plant (association). The amount of atmospheric nitrogen fixed by azotobacter ranges from 50 to 80 kg/ha a year, depending on the conditions in soil. Apart from fixing elementary nitrogen, azotobacter produces biologically active substances-auxins, gibberellin, pyridoxine, biotin, and nicotinic acid which can all contribute to plant growth. Therefore, azotobacter can also be used as a microbiological fertilizer in the production of non-legumes (Milić et al., 2004). Several inoculation treatments can be applied: introduction of azotobacter into soil before sowing it, seed inoculation before sowing, seedling inoculation, and introduction of azotobacter into soil by means of irrigation during the vegetation period.

The aim of this research was to observe the possibilities of using *Azotobacter chroococcum* in the growth and production of tomato and pepper by inoculating the seed and the seedling.

MATERIAL AND METHODS

The experiment was conducted in chernozem soil with two kinds of plants: tomato (Novosadski jabucar variety) and pepper (Kalifornijsko čudo variety). In autumn, manure was introduced in the soil. The variants in the experiment were seed inoculation, seedling inoculation, and control (no inoculation).

Seed inoculation consisted of immersing 50 g of tomato and pepper seeds in 15 ml of an inoculum containing 10^8/ml of *Azotobacter chroococcum* cells. The seeds were left in the inoculum for three hours.

Seedling inoculation was performed by immersing the root of seedlings in an inoculum containing 10^8/ml of *Azotobacter chroococcum* cells.

The sowing of inoculated and non-inoculated seed was performed in early April. The distance between seeds was 5 cm.

Thirty days after sowing, the plants were dug out and divided into three groups of thirty plants. The group I consisted of the plants whose seed was inoculated. The group II was the plants whose roots were inoculated, and the group III was the control plants that were not inoculated at all. All the plants were planted into rows. The distance between each plant was 30cm.

The effect of inoculation was observed thirty days after sowing, thirty days after transplanting and in the phase of technological maturity. The length and the dry matter of the plants were measured and the number and weight of fruits of tomato and pepper was determined.

RESULTS AND DISCUSSION

Thirty days after sowing there was no effect of *Azotobacter chroococcum* on the length of the plant above ground, root, or the whole plant of tomato (Table 1).

Tab. 1. — The effect of inoculation on the length of tomato plants

Variants		30 days after seeding		30 days after transplanting	
		Above ground (cm)	Root (cm)	Above ground (cm)	Root (cm)
Control		6.820	1.540	29.300	13.233
Inoculation of seed		6.800	2.060	35.000	20.033
Inoculation of seedlings				39.233	27.267
LSD	1%	2.523	0.937	0.814	0.928
	5%	1.521	0.565	0.491	0.560

Thirty days after transplanting, however, the effect of inoculation was statistically significant. The above ground part of the inoculated plants was lon-

ger by 6—10 cm than in the control plants, and the root of the inoculated plants was longer by 7—14 cm than the root of the control plants. A better effect was achieved when the seedlings were inoculated (table 1).

Thirty days after sowing the pepper, the length of the above ground part of the inoculated plants was smaller than the length of the control plants. The length of the root was the same in both inoculated and non-inoculated plants. However, thirty days after transplanting, the total length of the inoculated plants was greater by about 10—17 cm. As in tomato, the better effect was achieved with seedlings inoculation.

Tab. 2. — The effect of inoculation on the length of peppers plants

Variants		30 days after seeding		30 days after transplanting	
		Above ground (cm)	Root (cm)	Above ground (cm)	Root (cm)
Control		4.360	2.520	19.133	5.553
Inoculation of seed		2.580	2.540	27.200	7.433
Inoculation of seedlings				32.233	9.267
LSD	1%	2.358	2.358	1.243	2.497
	5%	1.422	1.422	0.750	1.505

Thirty days after transplanting, the dry matter mass of the inoculated plants, especially tomato, was greater than the dry matter mass of the non-inoculated plants. Seedlings inoculation had a better effect with both plants (table 3).

Tab. 3. — The effect of inoculation on dry matter mass of tomato and peppers plant

Variants		Dry matter mass of tomato plant (g plant^{-1})		Dry matter mass of peppers plant (g plant^{-1})	
		30 days after seeding	30 days after transplanting	30 days after seeding	30 days after transplanting
Control		0.11	12.25	0.069	7.17
Inoculation of seed		0.11	25.37	0.033	8.24
Inoculation of seedlings			52.43		9.45
LSD	1%	0.001	1.93	0.003	0.112
	5%	0.000	1.16	0.001	0.067

Inoculation with *Azotobacter chroococcum* had a significant effect on the number and weight of pepper and tomato fruits (Table 4). With tomato, the results were better when seedlings were inoculated. With pepper, seed inoculation was more effective.

Tab. 4. — The effect of inoculation on the number and weight of tomato and peppers fruits

Variants		Tomato		Peppers	
		Number of fruits per plant	Average weight of one fruit (g)	Number of fruits per plant	Average weight of one fruit (g)
Control		5.77	59.46	5.33	188.36
Inoculation of seed		7.72	78.50	6.36	231.53
Inoculation of seedlings		10.20	105.56	5.83	211.50
LSD	1%	1.35	0.788	1.42	15.12
	5%	0.81	0.475	0.86	7.43

The use of *Azotobacter chroococcum* in plant production was also justified in many earlier researches. Milošević et al. (1994) concluded that the same strains of *Azotobacter chroococcum* did not produce the same effect in different varieties of pepper. Govedarica et al. (1996) achieved faster germination when cucumber seed was inoculated before sowing. Govedarica et al. (1997) achieved a positive effect of azotobacter on the growth of pepper. The researches of Mrkovački and Milić (2001) showed that this bacterium increases the sugar content of sugar beet. In the researches of maize production by Govedarica et al. (2002) and Hajnal et al. (2004), an even germination, a 3% higher yield and an increased microbiological activity were achieved when *Azotobacter chroococcum* was applied. Jarak et al. (2006) achieved a positive effect of azotobacter on yield of wheat and on microbiological activity in wheat rhizosphere. Azotobacter can be used as an alternative to conventional nitrogen fertilizers. The use of *Azotobacter chroococcum* in tomato and pepper production could reduce the need for nitrogen mineral fertilizers, which is important both economically and ecologically.

CONCLUSION

— Thirty days after sowing there was no effect of *Azotobacter chroococcum* on the length and on the dry matter mass of tomato and pepper plants.

— Inoculation of tomato and pepper with *Azotobacter chroococcum* had a statistically significant positive effect on the length and weight of the plants thirty days after transplanting. A better effect was achieved when seedlings were inoculated.

— The number and weight of pepper and tomato fruits were significantly higher in inoculated variants. Seedling inoculation was more effective with tomato. Seed inoculation was more effective with pepper.

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КОРИСНОСТ ИНОКУЛАЦИЈЕ С АЗОТОБАКТЕРОМ НА РАСТЕЊЕ И НА ПРОДУКТИВНОСТ ПАРАДАЈЗА И ПАПРИКЕ

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Резиме

Азотобактер спада у слободне азотофиксаторе. У зависности од соја и услова средине, азотобактер може фиксирати 50 до 80 кг азота по хектару годишње. Осим што усваја елементарни азот, он продукује и материје које поспешују раст биљака. Због тих својстава азотобактер се примењује као биофертилизатор. Постоје различити начини примене азотобактера — у земљиште пре сетве, на семе и на расад.

Циљ истраживања је био да се испита ефекат примене *Azotobacter chroococcum* у производњи парадајза и паприке коришћењем два начина инокулације — инокулација семена и инокулација расада. Утицај инокулације испитиван је тридесет дана после сетве, тридесет дана после расађивања и у фази технолошке

зрелости. Испитивани су висина биљака, сува маса биљака, број плодова и маса свежих плодова.

Тридесет дана после сетве није било утицаја *Azotobacter chroococcum* на дужину и суву масу биљака. Инокулација парадајза и паприке имала је значајан утицај тридесет дана након расађивања. Бољи ефекат имала је инокулација расада. Број и тежина плодова код обе биљне врсте били су значајно већи на инокулисаним варијантама. Инокулација расада имала је бољи ефекат код парадајза док је код паприке бољи ефекат имала инокулација семена.