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INFLUENCE OF FOLIAR APPLICATION OF GUANO ON GRAIN YIELD OF DIFFERENT CORN HYBRIDS IN ORGANIC PRODUCTION

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Abstract

Studies were performed during 2011 and 2012 on experimental field of the Institute for Vegetable and Field Crops, In Department for Organic production and biodiversity in Bački Petrovac. The experiment was set up on certified plot, as two-factorial according to split plot design with four corn hybrids: ZP 555su, NS 620k, NS 609b and NS 6030 and two fertilization systems: foliar fertilization with organic fertilizer guano with increasing concentrations and treatment of seed corn variety by Azotobacter chroococcum strain also with three different concentrations. The aim of the study was to determine whether different concentrations of Azotobacter chroococcum strain with which the corn seed was treated and increasing concentrations of organic fertilizer guano, foliar applied through two fertilizations, affect the yield and quality of corn grain.

The results of two years lasting studies of joint action of foliar application of increasing guano concentrations and decreasing concentration of Azotobacter strain in hybrids NS 620k and hybrid NS-6030, significantly increased corn grain yield in comparison to the unfertilized control variant. In the treatment with the highest applied concentration of guano in fertilization, and the lowest concentration of Azotobacter chroococcum for popping corn seed treatment, statistically higher yield was achieved in comparison to the treatments with lower concentrations of the applied fertilizer and bacterium strain. Statistically, higher yield of hybrid NS 620k was achieved in 2011, at all treatments with joint action of guano and Azotobacter, in relation to the treatments only by Azotobacter chroococcum.

Key words: organic farming, guano, Azotobacter chroococcum, corn yield.

Introduction

Production of organic corn in Serbia started recently and it is grown in small areas. However, number of organic food producers in Serbia keeps increasing due to growing market demand for healthy food (Čuvardić et al., 2006). Corn is primarily used as cattle feed, such as grain or silage, as raw material for industrial processing, but also as vegetables, seasoning, indispensable in many products of national cuisine, for making salads, popcorn, etc. Low in calories, and on the other hand with a lot of useful substances such as proteins, vitamin A, followed by group B, C and E, minerals Ca, Mg, Zn, Mn, beta carotene, starch, unsaturated fatty acids, etc**.** Basic principles of organic production systems include use of only natural inputs, i.e. application of cultural practices that preserve natural resources and enrich biodiversity (Bekavac, 2012). Corn has a high demands toward soil, nutrients and water, and therefore pronounced negative impact on resources and agroecosystems. In organic production system, use of more different sources of nutritive elements such as: soil organic matter, organic and natural fertilizers, cultivation of legumes and ploughing and/or composting of crop residues, application of biofertilizers is recommended. Increase in organic matter content in soil is a key precondition of organic production, as organic matter is the most important source of plant nutrients. However, very small amount of nutrients from organic matter is available to plants (Steen, 1994). General rule is that soils with a higher content of organic

matter have also higher number of microorganisms, and presence of microbiological communities depends on organic matter chemical composition (Bending & Rayns 2000). For this reason, use of organic fertilizers and some P and K fertilizers is allowed in organic production. Positive effect of fertilizers application is in increase of soil fertility and biological activity (Bogdanović et al. 1995; Bo Liu et al. 2007). Microbiological fertilizers – biofertilizers contain chosen cultures of microorganisms and are used for inoculation of seed and nursery plants, or are incorporated into the soil in order to intensify certain microbiological processes that increase content of available plant nutrients (Jarak and Đuric 2008). Azotobacter fixes elemental nitrogen and produces biologically active matters and group B vitamins. Biologically active matters have beneficial effect on germination, growth of seedlings, plant growth and development (Mrkovački & Mezei 2003).
Therefore, the aim of the study was to determine whether combined action of Azotobacter chroococcum strain –with which seed of three corn hybrids was inoculated and liquid organic fertilizer guano, with foliar application through two fertilizations, as the source of nitrogen, affect the yield and quality of corn grain in organic production.

Materials and methods

Studies were carried out during 2011 and 2012 on experimental field of the Institute for Vegetable and Field Crops**.** The experiment was set up on certified plot for organic production, as two-factorial according to split plot design in four replications. The experiment included four corn hybrids: NS 620k; NS 609b; NS 6030 ; ZP 555 šu, (in the paper are presented results for the first three hybrids) and two fertilization systems: the first system is application of biofertilizers – corn seed treatment by Azotobacter chrococcum strain, and the second system is foliar application of organic fertilizer guano (7:3:5) in two fertilizations.

Fertilization treatments:
Unfertilized - (control)
A1 + FG1 (Azotobacter chrococcum $1x10^8$ + 2% guano solution)
A2+ FG2 (Azotobacter chrococcum $1x10^6$ + 4% guano solution)
A3+ FG3 (Azotobacter chrococcum $1x10^4$ + 6% guano solution)
Before setting up of the experiment, soil samples for agrochemical analysis were taken from the layers of 0-3 and 30-60 cm (Table1).

Table1. Agrochemical soil properties before setting up experiment

Godina	Dubina	pH		%	%	%	N min.	mg $100g^{-1}$	
	cm	H_2O	KCl	$CaCO_3$	Humus	N	(0-120cm)	P_2O_5	K_2O
2011	0-30	8,00	7,17	5,44	2,87	0,14	71,87	18,94	22,93
	30-60	8,07	7,30	9,62	2,37	0,12		9,76	19,80
2012	0-30	8,06	7,19	4,62	2,63	0,13	42,89	22,27	22,66
	30-60	8,26	7,39	14,70	2,00	0,11		6,77	17,19

According to Table 1, soil in the experiment with corn is neutral to alkaline, medium to highly calcareous, in the middle class provided by humus and total nitrogen, with easily available phosphorus well provided in the first layer and in the second poorly, while in easily available potassium belongs to the class of good to medium provided soil. For agrochemical soil analysis standard methods were used.
For the purpose of monitoring dynamics and distribution of NO_3 – N per profile, soil samples were taken: before sowing, in the phase of tasseling and before corn harvest per layers of 0-30; 30-60; 60-90; and 90-120 cm. NO_3- N was determined by N min. method of Scharpft and Wehrmann (1978). Grain yield, cobs per repetition and moisture were measured. Statistical data analysis

(ANOVA) was accomplished using the software GenStat Release 9.1 (Rothamsted Experiment Station, Trial Version).

Weather conditions in the analyzed years (according Latkovic 2013) indicate that the two years were extremely dry, in growing season 2011 fell only 212 mm of rainfal, i.e. for 148 mm less than LTA (360 mm). Also, in 2012, in comparison to LTA in growing season fell 130 mm less rain. However, winter moisture supplies (October – March) in 2011 were somewhat more convenient (266 mm), compared to 2012 (only 200 mm; i.e. 55 mm less in relation to LTA values). Thermal conditions in the analyzed years also did not support corn cultivation. In both years the average temeprature values for growing seasons were higher in comparison to LTA, which was particularly pronounced in 2012 in three critical summer months (June, July, August) when the average monthly air temperatures significantly exceeded LTA values

Results and Discussion

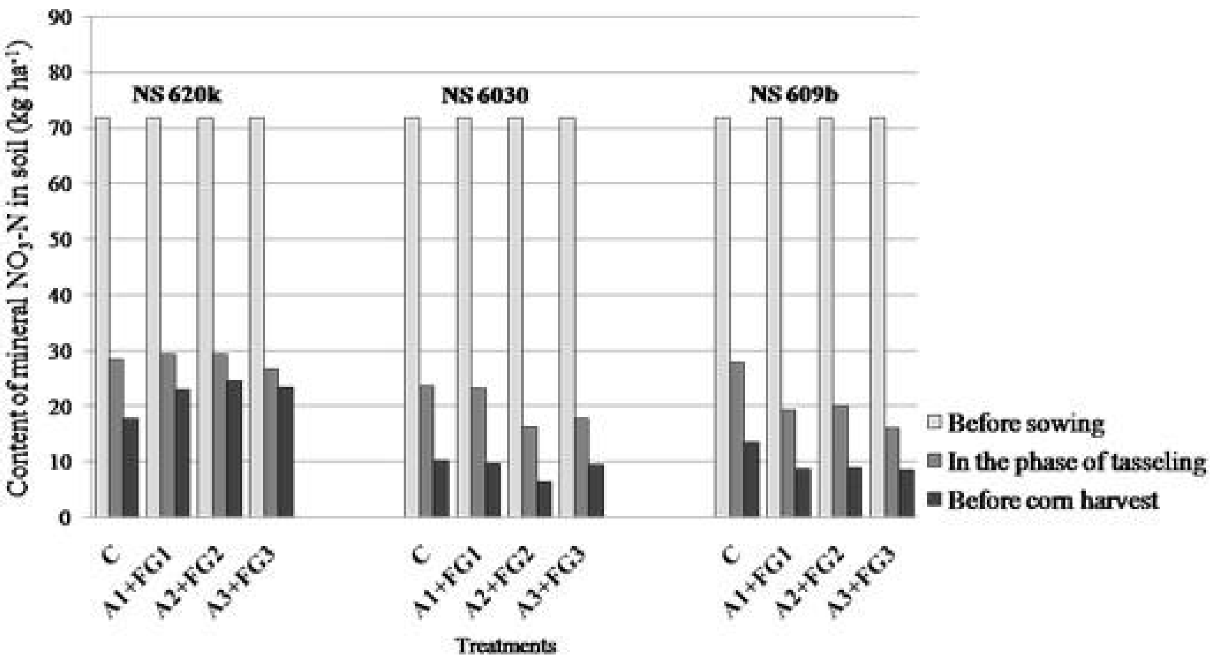
In Table 2 are presented yields of three corn hybrids per fertilization treatments in studied years. Results of F-test show that in 2011 there existed statistically highly significant difference in grain yield between the studied hybrids. In 2012 between grain yield of the hybrid NS 620k and other two hybrids existed statistically significant difference, while it did not exist between grain yield of the hybrids NS 609b and NS 6030. The highest average grain yield in both years had hybrid NS 6030, and the lowest NS620k. Significantly higher grain yield achieved for all three hybrids in 2011 in comparison to 2012 can be explained by favourable climatic conditions, larger reserve of the available winter moisture and lower temperatures in 2011 growing (Latković et al., 2013).

Table 2. Yield of corn hybrids as dependent on fertilization treatments in 2011 and 2012.

Hybrids	**NS 620k** (H) t ha^{-1}		**NS 6030** (H) t ha^{-1}		**NS 609b** (H) t ha^{-1}	
Treatmens (T)	Year (Y)		Year (Y)		Year (Y)	
	2011	2012	2011	2012	2011	2012
C	4,403	2,378	10,656	5,199	8,746	5,009
A1	4,971	1,781	10,901	5,492	8,591	5,470
A1 + FG1	4,425	2,749	10,322	6,425	9,056	4,924
A2	4,887	1,762	10,753	6,900	8,866	5,811
A2 + FG2	4,288	2,135	10,615	6,283	8,969	5,549
A3	4,301	4,301	10,956	6,397	8,925	5,137
A3 + FG3	4,730	4,730	10,807	6,063	9,041	5,339
	LSD	Treatmens 2011	Hybrid 2011	Treatmens 2012	Hybrid 2012	
	0,05	0,4973	0,4553	0,7821	0,8668	
	0,01	0,661	0,6898	1,0395	1,3132	

In comparison to highly significant differences in grain yield between various hybrids, the applied fertilization treatments had lower impact to the yield. In 2012, for hybrid NS 620k treatments A3 and A3+FG3 resulted in significantly higher grain yields in relation to all other fertilization treatments and control. Grain yield of the hybrid NS 6030 in 2012 in all treatments with foliar application of guano and Azotobacter was statistically higher in comparison to the treatment with Azotobacter alone in the lowest concentration (A3) and control – without fertilization. On the other hand, in 2011 for the same hybrid significant difference in grain yield was established only between treatment A1 in comparison to the treatment A1+FG1. In 2012 the same hybrid had significantly higher yield at treatment A1 compared to treatment A3 and control.

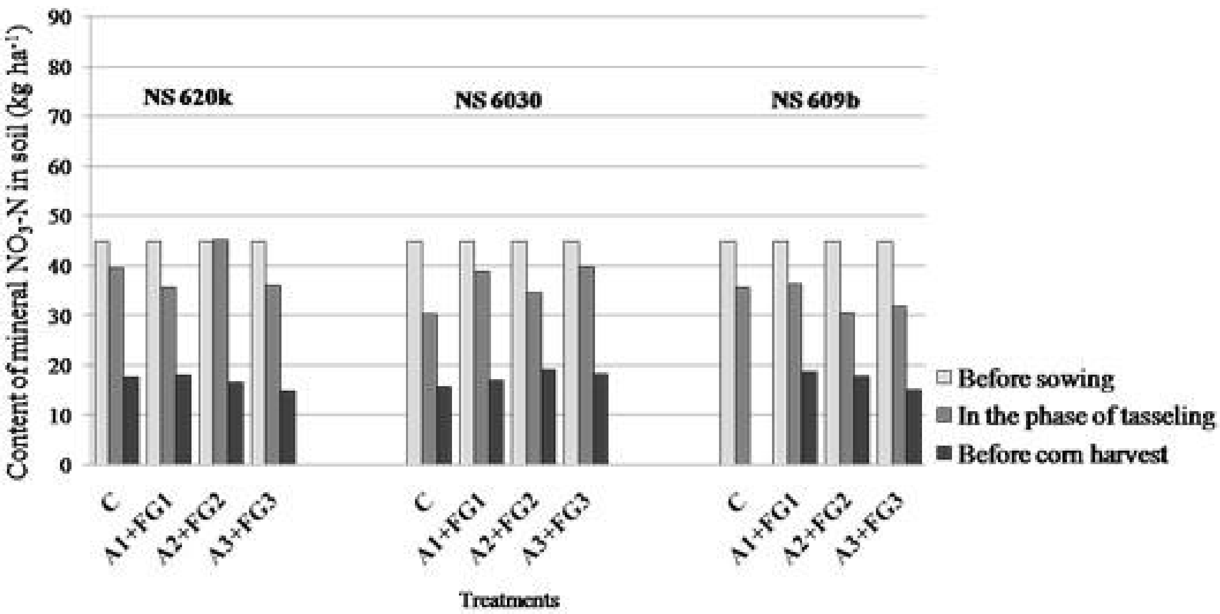
On Graph. 1 and 2 dynamics of NO_3-N in the soil is presented: before sowing, in the phase of tasseling and before harvest of the corn hybrid. In organic production corn plants absorb mineral nitrogen from the soil produced by mineralization of organic matter, while in conventional production in addition to mineral nitrogen from organic matter (depending upon soil fertility), plants absorb also nitrogen from the applied mineral N-fertilizers (Bogdanović et al., 2010). In both years of the study before sowing of corn hybrid according to the measured quantities of NO_3- N, the soil was in the class of good assurance (Graph 1 and 2), although the experiment was performed on the plot that was for many years used in organic farming – without use of mineral N-fertilizers (every four years it is fertilized by manure).



Legend for Graph 1. and Graph 2: C - unfertilized control; A1 FG1 - Azotobacter chroococcum 1x10^8 + guano solution 2%; A2 FG2 - Azotobacter chroococcum 1x10^6 + guano solution 4%; A3 FG^3 - Azotobacter chroococcum 1x10^4 + guano solution 6%

Graph 1. NO_3-N dynamics in the soil under different corn hybrids in 2011.

Good assurance of the soil by NO_3-N before sowing of the corn hybrid can be explained by mineralization of organic matter of the soil (soil humus content in the experiment was between 2.63 and 2.87%), crop residues and roots of previous crop and microbial biomass (Bogdanović and Ubavić 2008; Manojlović et al. 2008**).** In these studies, treatments of corn seed by different concentrations of Azotobacter chroococcum strain were performed in order to supply corn crop by mineral nitrogen over fixation of elemental nitrogen, with two foliar applications of organic fertilizer guano during growing season. Studies of Govedarica et al.(2001) suggest that use of certain bacteria strains in conventional corn production can lower quantities of N-fertilizers, and thus lower costs of production. Use of biofertilizers in corn production provides cheaper and ecologically highly valuable food (Hajnal and Govedarica 2004). According to the studies Hajnal and Govedarica (2004) microorganisms - diazotrophs have positive effect on seed germination, growth of seedlings, growth and development of plants and also on the yield and its quality not only by fixing elemental nitrogen, but also by producing some other biologically active substances (such as hormones and vitamins). Monitoring of NO_3-N dynamics in the soil under experiment, from planting to harvest of corn hybrids, per dates of sampling, revealed that its quantities reduce in view of the crop demands for nitrogen during growing season and depending on the hybrid.



Graph 2. NO_3-N dynamics in the soil under different corn hybrids in 2012.

Conclusion

Based on results of two years researches in field experiments with three hybrids the following can be concluded:

In experiments carried out in 2011, all three hybrids in all fertilization treatments had statistically significantly higher yield in comparison to grain yield in 2012.

In 2011 statistically significant difference was established between grain yields for all three corn hybrids.

In 2012 significant difference was established between grain yield of the hybrid NS 620k and the other two hybrids, while between hybrids NS 6030 and NS 609b significant difference did not exist.

Influence of fertilization systems: treatment of the hybrid corn seed by Azotobacter chroococcum strain and foliar fertilization by different concentrations of organic fertilizer guano had significantly lower effect to grain yield in relation to the effect of hybrids in both years of the study.

In 2012 all three guano concentrations for fertilization of the hybrid NS 6030 in comparison to control showed statistically significant effect to the grain yield.

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