RESEARCH ON THE PRESENCE OF COPPER IN MAIZE SEEDS UNDER THE INFLUENCE OF CHEMICAL FERTILIZERS

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Abstract

Maize is a very important plant for fodder in the North West part of Romania and this paper presents long term trials research results from Agricultural Research and Development Station Oradea. Were studied copper concentration of maize seeds harvested from four variants fertilized with different doses of chemical fertilizers with nitrogen, phosphorus and potassium.

Average copper concentration in maize, for the three years under study (2010-2012) in the control was 2.840 mg/kg. In variant $N_{80}P_{40}K_{40}$ there was a higher concentration of 7.5% compared to unfertilized variant, of 3.052 mg/kg, being statistically insignificant.

The maize harvested from the variant fertilized with $N_{80}P_{80}K_{80}$ had a higher copper concentration by 12.9% compared to the control. The fertilized variant $N_{160}P_{80}K_{120}$increased the concentration of copper of 3.336 mg/kg, 17.5% higher compared to the variant $N_0P_0K_0$ (control), being statistically significant.

Key words: copper, maize, seeds, nitrogen, phosphorus, potassium, fertilizers.

INTRODUCTION

Fertilizers are components usually applied to the soil, taken by plants for growth and development, by absorption through plant roots or foliar feeding by leaf-absorption. Fertilizers can be organic (organic compounds) or chemical (consisting of simple chemicals or minerals) (Ciobanu, 2002).

The usual fertilizers provide, in different proportions, the essential macroelements of the plants (N, P, K), secondary microelements (Ca, S and Mg) and sometimes the microelements with a role in plant nutrition (B, Cl, Mn, Fe, Cu and Mo) (Nicholas and Egan, 1975).

One of the microelements needed for plant nutrition is copper. Soils with a low copper content may lead to the occurrence of plant deficiency symptoms, and those with a concentration above the maximum admissible limits lead to phytotoxicity. Small quantities of copper are needed in human and animal nutrition, but larger amounts may be toxic for animals and humans (Irwin et al., 2007).

The anthropogenic sources of copper pollution are copper mining and processing, the electric conductors industry, pesticides used in agriculture, wastewater from pig farms and steel (Hejcman et al., 2013).

The accessibility of heavy metals for plants is not constant but varies both according to species and environmental conditions: climate, soil (Salwa A.I., 2009). Salad, opposite with carrots and potatoes, has a greater

capacity to accumulate heavy metals, especially zinc, copper and cadmium, and the clover absorbs copper faster than grasses. The tolerance levels of the various heavy metal cultures are in decreasing order: herbage, grasses, cereals, potatoes and sugar beet (Hough et al., 2003).

Kabata-Pendias A. and Pendias H. (2001) show that copper phytotoxic concentration is 20 - 100 mg Cu/kg in dry matter.

In experiments performed by Kastori, et al. (2007) with triticale, wheat, poppy, peas and corn it was shown that the translocation of some elements (Ni, Cu, Zn, Mo, Sr and Ba) in the seeds was the lowest for corn. Their assimilation is influenced by species, genotype, growth phenophase, plant organ, perspiration, chemical properties and concentration in toxic elements, soil conditions (Kastori R. et al., 2004). Research by Kastori et al. (2006) shows that for triticale the translocation of nickel, copper and zinc from the vegetative parts in the seeds was intensive, while that of the molybdenum was medium.

On the other hand, Nemeth T. and Kadar I. (2005) found no significant translocations from the soil in the plant in the case of As, Hg, Ni, Cu, Pb. In the case of application of phosphorus fertilizers, the concentration of copper in wheat grains tends to decrease (Gyori, 2007).

This paper shows the influence of the NPK fertilizers over copper concentration in maize seeds.

MATERIAL AND METHOD

The maize seeds was harvested in the long term trials at the Agricultural Research and Development Station Oradea, in 2010 – 2012 period.

Variants studied:

V_1 - $N_0P_0K_0$,

V_2 - $N_{80}P_{40}K_{40}$,

V_3 - $N_{80}P_{80}K_{80}$,

V_4 - $N_{160}P_{80}K_{120}$

Laboratory investigations were carried out in the ***"Research Laboratory of risk factors for Agriculture, Forestry and the Environment",*** Faculty of Environmental Protection Oradea.

Mineralization of plant biological material samples in order to determine the copper was done with a mixture of sulfuric and perchloric acids.

Samples of vegetal biological material were prepared according to the working methods and analyzed with a spectrophotometer with atomic absorption SHIMADZU AA-6300 to determine the concentration of copper.

The links between different doses of chemical fertilizers with NPK and copper concentration in maize seeds were calculated using Microsoft Excel program; of the 5 types of functions available on the program (linear, exponential, logarithmic, polynomial and power) was chosen the function with the highest value of R^2.

RESULTS AND DISCUSSIONS

In maize seeds, the lowest copper concentrations were recorded in the $N_0P_0K_0$ variants, 2.877 mg/kg in 2010, 2.836 mg/kg in 2011, respectively 2.807 mg/kg in 2012. In the $N_{80}P_{40}K_{40}$ variant the concentration of copper in maize was 8.6% higher (3.124 mg/kg) in 2010, 7.2% (3.040 mg/kg) in 2011 and 6.6% (2.992 mg/kg) in 2012, the differences being not statistically assured.

In case of fertilized variant with $N_{80}P_{80}K_{80}$ the recorded differences are higher than those in the control variant by 14.1% (3.283 mg/kg) in 2010, 12.6% (3,193 mg/kg) in 2011, respectively 12.1 % (3,147 mg/kg) in 2012. Only in 2010 the recorded difference was statistically ensured, being "significant".

The highest differences from the $N_0P_0K_0$ variant were recorded in the $N_{160}P_{80}K_{120}$ fertilized version, with concentrations of 3.409 mg/kg in 2010, 3.321 mg/kg and 3.279 mg/kg, 18.5% higher, 17.1% respectively 16.8%, being statistically significant. The results were presented in Table 1.

The maize seeds analyzed from the NPK experience did not exceed the maximum permitted copper limit for maize, 5 mg/kg, as established by the Order of the Ministry of Health no. 975/1998. In the control variants, the copper concentration of maize was 57.5% in 2010, 56.7% in 2011 and 56.1% in 2012 compared to the maximum allowed. For the $N_{80}P_{80}K_{40}$ variant, the analyzed maize seeds had a copper concentration of 62.5% in 2010, 60.8% in 2011, and 59.8% in 2012 compared to the maximum allowed. The copper concentration of maize samples taken from variant $N_{80}P_{80}K_{80}$ was 65.7% in 2010, 63.9% in 2011, and 62.9% in 2012 compared to the maximum admissible limit. In the fertilized variant with $N_{160}P_{80}K_{120}$, maize grains had a copper concentration of 68.2% in 2010, 62.4% in 2011 and 65.6% in 2012 of the maximum admissible limit value (Figure 1).

Table 1

The influence of doses and combinations of NPK fertilizers on copper concentration in maize seeds

Variant	Cu concentration		Difference		Statistical significance
	mg/kg	%	mg/kg	%	
2010					
$N_0P_0K_0$	2,877	100	-	-	Control
$N_{80}P_{40}K_{40}$	3,124	108,6	0,247	8,6	-
$N_{80}P_{80}K_{80}$	3,283	114,1	0,406	14,1	*
$N_{160}P_{80}K_{120}$	3,409	118,5	0,532	18,5	*
		LSD 5%	0,324		
		LSD 1%	0,592		
		LSD 0,1%	0,976		
2011					
$N_0P_0K_0$	2,836	100	-	-	Control
$N_{80}P_{40}K_{40}$	3,040	107,2	0,204	7,2	-
$N_{80}P_{80}K_{80}$	3,193	112,6	0,357	12,6	-
$N_{160}P_{80}K_{120}$	3,321	117,1	0,485	17,1	*
		LSD 5%	0,378		
		LSD 1%	0,608		
		LSD 0,1%	0,996		
2012					
$N_0P_0K_0$	2,807	100	-	-	Control
$N_{80}P_{40}K_{40}$	2,992	106,6	0,185	6,6	-
$N_{80}P_{80}K_{80}$	3,147	112,1	0,340	12,1	-
$N_{160}P_{80}K_{120}$	3,279	116,8	0,472	16,8	*
		LSD 5%	0,362		
		LSD 1%	0,570		
		LSD 0,1%	0,890		

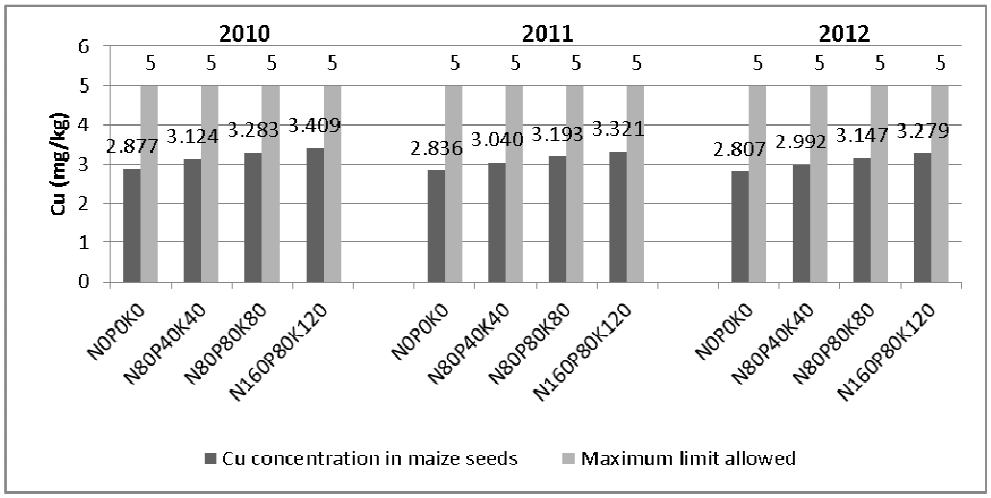

Fig. 1. Graphical representation of copper values in maize grains based on doses and combinations of NPK fertilizer compared to the maximum limit allowed

In the three years under study (2010-2012), average copper concentration in maize in the control was 2.840 mg/kg. In $N_{80}P_{40}K_{40}$ variant there was a higher concentration of 7.5% compared to unfertilized variant, of 3.052 mg/kg, being statistically insignificant. The maize harvested from the variant fertilized with $N_{80}P_{80}K_{80}$ had a higher copper concentration by 12.9% compared to the control. The fertilized variant $N_{160}P_{80}K_{120}$increased the concentration of copper of 3.336 mg/kg, 17.5% higher compared to the variant $N_0P_0K_0$ (control), being statistically significant (Table 2).

Table 2

The influence of doses and combinations of NPK fertilizers on copper concentration in maize grains, average data, (2010-2012)

Variant	Cu concentration		Difference		Statistical significance
	mg/kg	%	mg/kg	%	
$N_0P_0K_0$	2,840	100	-	-	Control
$N_{80}P_{40}K_{40}$	3,052	107,5	0,212	7,5	-
$N_{80}P_{80}K_{80}$	3,207	112,9	0,367	12,9	-
$N_{160}P_{80}K_{120}$	3,336	117,5	0,496	17,5	*
		LSD 5%	0,355		
		LSD 1%	0,590		
		LSD 0,1%	0,954		

The mathematical modeling of the copper concentration results from maize grains harvested from the experience with nitrogen, phosphorus and potassium shows that the polynomial function is the best statistically assured, $y = -0{,}014x^2 + 0{,}242x + 2{,}614$, $R^2 = 0{,}938$. (Figure 2)

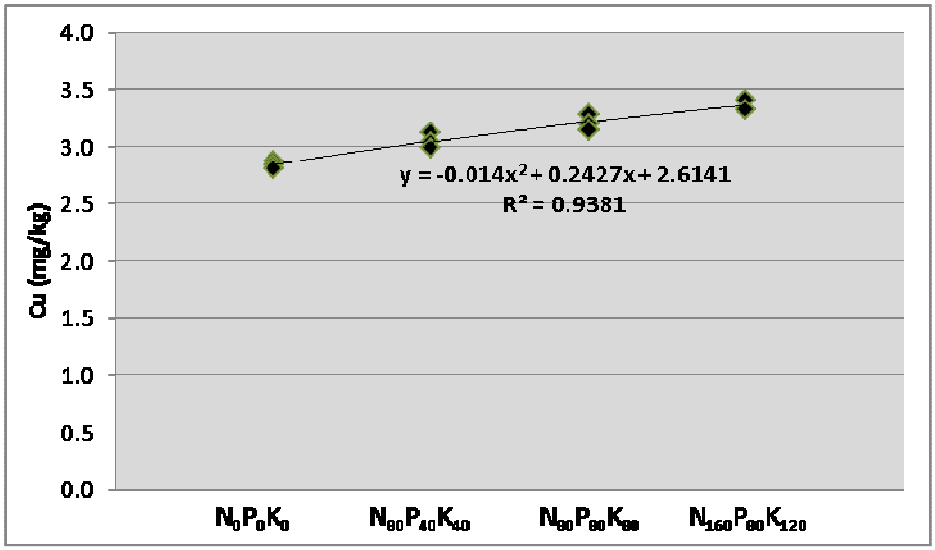

Fig. 2. Correlation between doses of NPK fertilizers and copper concentration in maize seeds

CONCLUSIONS

Compared to the unfertilized control in all the studied variants the copper concentration from maize seeds increased.

The highest copper concentration was in $N_{160}P_{80}K_{120}$ variant in 2010 (3.409 mg/kg) with 18.5% higher than control, being statistically significant.

In average, the variant fertilized with $N_{160}P_{80}K_{120}$ increased the concentration of copper of 3.336 mg/kg, 17.5% higher compared to the variant $N_0P_0K_0$, being statistically significant.

The maize seeds harvested from the nitrogen, phosphorus and potassium experience did not exceed the maximum permitted copper limit for maize.

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