INFLUENCE OF FERTILIZATION WITH NITROGEN, PHOSPHORUS AND POTASSIUM ON THE CONCENTRATION OF LEAD IN CEREAL GRAINS

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Abstract
   The annual application of fertilizers with nitrogen, phosphorus and potassium to wheat and maize cultures leads to an increase the concentration of heavy metals in their seeds. For this purpose,during the period 2010-2012, was studiedthe effect of application of different doses of chemical fertilizers on the lead concentration of wheat and maize grains.
   The results showed that with the gradual increase of the chemical fertilizer doses, the lead concentration of the cereal grains also increased. Statistically significant differences from the non-fertilized control were recorded for both grains, 0.046 mg/kg for wheat seeds and 0.059 mg/kg for maize grains respectively, in variant fertilized with $N_{160}P_{80}K_{120}$.
   Lead concentrations did not exceed the maximum permitted limit of 0.2 mg Pb/kg, according to ORDER (EC) No. 1881/2006.

Key words:lead, wheat, maize,seeds, nitrogen, phosphorus, potassium

INTRODUCTION

Knowing the interaction between soil, plant and fertilizers in the course of the entire vegetation period is one of the most important factors in the scientific direction of the agricultural production process for the purpose achieving superior crops in terms of quantity and quality (Ciobanu G., 2011).

Application of fertilizers in accordance with observance of all technological links ensures the optimization of the attributes physical and chemical as well as the soil's trophic regime ensuring preservation or even the increase of fertility in the conditions of ensuring the optimal requirements of cultivated plants (Borlan Z. and Hera C., 1984).

Chemical fertilizers sometimes return to the soil all the mineral elements, which are gradually taken from the soil along with the productions. This phenomenon is related to the continuous impoverishment of soil in elements not included in applied fertilizers (Brooks L.L., 1994).

The nutritional value of plants intended for human and animal consumption is clearly improved when mineral fertilizers are used rationally (Banu C., 2007).

In the horizon A of different soil types, the lead concentration is typically between 5 and 280 mg/kg, with an average of 30 mg/kg (LăcătuşuR., 2006). The mean lead concentration in soils in Europe was 22.6 mg/kg (Salminen R. et al., 2005). In Poland, the lead concentration was between 6 and 102 mg/kg (Pendias A. Kabataand Pendias H., 2001), and in the United Kingdom, the largest limits were 3 - 16,338 mg / kg (McGrath S.P. and Loveland P.J., 1992).

In case of wheat crops, application of different doses of NPK and different lead doses (0 - 20 µg/g) determined the lead concentration in berries and straw to be exceeded without exceeding the maximum allowed, with no adverse effect on animals and people (Salwa, AI, 2009). It has been demonstrated that it is possible to predict the cadmium and lead concentrations of wheat grain depending on the total soil content in heavy metals, comparative with copper and zinc whose concentrations cannot be predicted by this indicator (Z. Nan and et al., 2002, Hough R.L. et al., 2003). Wastewater irrigation leads to increased concentrations of heavy metals (Cu, Cr, Mn, Ni, Pb and Zn) from the roots, stems and seeds of wheat plants, the most significant increase being recorded for manganese and zinc (M. Karatas et al., 2006).

It was found that the reaction of plants to heavy metals, maize, wheat, clover, soybean and sunflower was different at high lead levels, as the highest lead concentrations were recorded in the following order: maize>clover>soybean>sunflower>wheat (Abd El-Aziz et al., 2009).

This study shows the influence of the nitrogen, phosphorus and potassium fertilizers over lead concentration in winter wheat and maize seeds.

MATERIAL AND METHOD

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

Studied variants were:V_1 – $N_0P_0K_0$ (control); V_2– $N_{80}P_{40}K_{40}$; V_3– $N_{80}P_{80}K_{80}$; V_4– $N_{160}P_{80}K_{120}$.

The studied vegetal biological material was the wheat variety Crişana and hybrid maizeFundulea 376.

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

Mineralization of plant biological material samples in order to determine the lead was done with a mixture of H_2SO_4 and $HClO_4$ acids.

For the determination of lead under study, samples of vegetal biological material prepared according to the working methods presented above were analyzed by spectrophotometer with atomic absorption SHIMADZU AA-6300.

Correlations between nitrogen, phosphorus and potassium doses and lead concentrations in wheat and maize seeds were calculated using Microsoft Excel and was chosen the function with the highest value of R^2.

RESULTS AND DISCUSSIONS

In $N_0P_0K_0$ variant (control) over the three years studied, on average, the lead concentration in wheat grains was 0.037 mg/kg. In variant fertilized with $N_{80}P_{40}K_{40}$ was registered a higher concentration of 0.041 mg/kg, with 9.4% compared to the unfertilized variant. In the variant fertilized with $N_{80}P_{80}K_{80}$ the wheat grains had a higher lead concentrations by 16.7%, respectively 0.007 mg/kg higher compared to the control. The variant $N_{160}P_{80}K_{120}$ lead to an increase of the lead concentration 22.7% compared to the $N_0P_0K_0$ variant. In variants $N_{80}P_{40}K_{40}$ and $N_{80}P_{80}K_{80}$ the differences were not statistically assured and in variant $N_{160}P_{80}K_{120}$ the difference was statistically significant (Table 1).

Table 1

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

Variant	Pb concentration		Difference		Statistical significance
	mg/kg	%	mg/kg	%	
$N_0P_0K_0$	0.037	100	-	-	Control
$N_{80}P_{40}K_{40}$	0.041	109.4	0.004	9.4	-
$N_{80}P_{80}K_{80}$	0.044	116.7	0.007	16.7	-
$N_{160}P_{80}K_{120}$	0.046	122.7	0.008	22.7	*
	LSD 5%	0.008			
	LSD 1%	0.012			
	LSD 0.1%	0.020			

The mathematical modeling of the lead concentration data in wheat grains from the four variants of the nitrogen, phosphorus and potassium experience studied shows that the power function best quantifies the relationship between chemical fertilizer doses and the lead concentration in wheat grains, $R^2 = 0.634$. The results were presented in Figure 1.
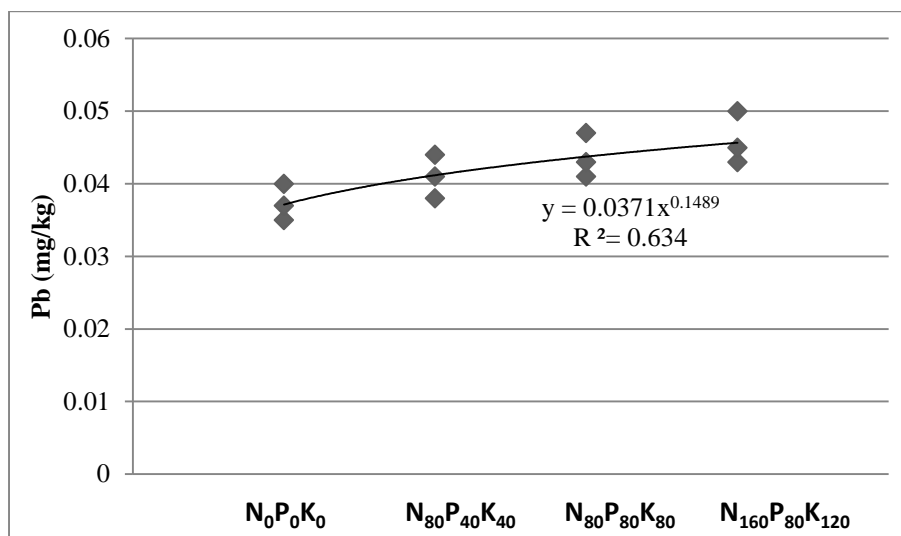
Fig. 1.Correlation between doses of NPK fertilizers and lead concentration in wheat seeds

On average, over the three years studied, the lead concentration in control variant of maize grains was 0.048 mg/kg. In variant $N_{80}P_{40}K_{40}$ was registered a higher concentration of 11.2% compared to the unfertilized variant, the 0.053 mg/kg, was not statistically significant. The maize harvested within $N_{80}P_{80}K_{80}$ variant had higher lead concentration by 19.9% compared to variant $N_0P_0K_0$. In this variant the difference was not statistically insured. The fertilized variant $N_{160}P_{80}K_{120}$ led to an increase of lead concentration at 0.059 mg/kg, 24% higher compared to the control variant, being statistically insured (Table 2).

Table 2

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

Variant	Pb concentration		Difference		Statistical significance
	mg/kg	%	mg/kg	%	
$N_0P_0K_0$	0.048	100	-	-	Control
$N_{80}P_{40}K_{40}$	0.053	111.2	0.005	11.2	-
$N_{80}P_{80}K_{80}$	0.057	119.9	0.009	19.9	-
$N_{160}P_{80}K_{120}$	0.059	124.0	0.011	24.0	*
	LSD 5%	0.010			
	LSD 1%	0.021			
	LSD 0.1%	0.032			

The mathematical modeling of the lead concentration results in maize seeds from the NPK experience studied shows that the power function is best provided statistically, $y = 0.0476x^{0.158}$, $R^2 = 0.745$ (Figure 2).
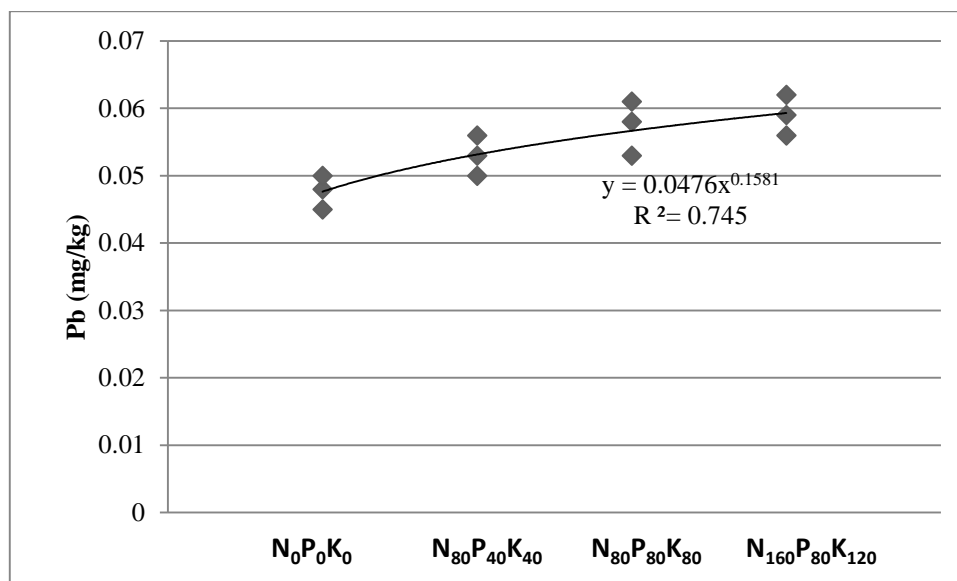
$$y = 0.0476x^{0.1581}$$
$$R^2 = 0.745$$

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

CONCLUSIONS

In case of wheat seeds, the lowest lead concentration was determined in the control variant, 0.037 mg/kg, and the highest in the $N_{160}P_{80}K_{120}$ variant, 0.046 mg/kg, higher by 22.7% compared to the unfertilized control.

In maize culture, application of the 160 kg N/ha, 80 kg P/ha and 120 kg K/ha doses resulted an increase in the lead concentration of the seeds by 24% compared to the unfertilized variant.

Application of chemical fertilizers with nitrogen, phosphorus and potassium in moderate doses leads to statistically insignificant increases in the lead concentration of wheat and maize seeds.

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