

THE INFLUENCE OF CHEMICAL AND ORGANIC FERTILIZERS ON THE CONCENTRATION OF CADMIUM IN WHEAT AND MAIZE GRAINS

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Abstract

This paper presents research results on the effects of applying different doses of nitrogen, phosphorus and manure fertilizers on the concentration of cadmium in wheat and maize grains harvested from a long experiment established in 1980.

In the three years studied, it was observed that by the combined application of chemical fertilizers and manure, the increases in the concentration of cadmium in wheat and maize grains were between 0.003 and 0.011 mg / kg, respectively 0.003 and 0.009 mg / kg.

Research has shown that wheat seeds have a higher capacity to accumulate cadmium compared to corn grains.

Key words: cadmium, wheat, maize, seeds, chemical, organic, fertilizers.

INTRODUCTION

Vegetables, grains and meat are essential in human nutrition. They can be contaminated with different levels of heavy metals (Ross S.M., 1994).

The nutritional value of plants intended for human and animal consumption is obviously improved when mineral fertilizers are used rationally (Nicholas D.J., Egan A.R., 1975).

An important source of heavy metal pollution is agriculture through the inputs used (chemical fertilizers, organic fertilizers, pesticides, irrigation water). The systematic and prolonged application of phosphorus and zinc fertilizers leads to an increase in the accumulation of cadmium in soils and implicitly in plants (Adams M.L. et al., 2004).

Heavy metals are being given special attention around the world due to their toxic effect even at very low concentrations. A number of cases of disorders, diseases, malformations of the organs caused by the toxicity of heavy metals have been reported. Some heavy metals can be stored in soil, plants and animals, reaching the human body through the food chain.

There are data on the increase in the accumulation of arsenic, cadmium and uranium in the fields treated with phosphate fertilizers. The concentration of cadmium higher than 100 mg/kg in phosphate rocks

increases the contamination of the soil with cadmium. Uranium is another example of a contaminant often found in phosphorus fertilizers. Phosphate rocks contain different amounts of these elements and if no specific cleaning technologies are applied, after mining, the systematic application of phosphorus fertilizers leads to the accumulation of these elements in the soil, which can reach high levels for agricultural crops, human and animal health (Barisic D., et al. 1992).

According to A. Singh and M. Agrawal (2001), the application of manure can reduce by 32%, 47%, 42%, 21%, 24%, 47% and 38% the concentrations of Cd, Cu, Pb, Zn, Mn, Ni, and Cr respectively from soils fertilized for long periods with NPK chemical fertilizers (Vușcan A., 2014, 2017, 2019, 2020).

MATERIAL AND METHOD

The wheat and maize were harvested in 2014 – 2016 period from the long term trials with chemical and organic fertilizers to the Agricultural Research and Development Station Oradea, Romania.

The crop rotation was: bean – winter wheat – sunflower – maize – winter wheat.

The elements of technologies utilized was respected the most recent recommendations in this area.

In experiment with phosphorus, nitrogen and farmyard manure fertilizers, the experimental factors were:

- a. nitrogen and phosphorus rates: N_0P_0 , $N_{50}P_0$, $N_{50}P_{50}$, $N_{100}P_{100}$.
- b. farmyard manure rates: 0 t/ha, 20 t/ha, 40 t/ha, 60 t/ha.

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

To determine the cadmium concentration, the plant samples were mineralized 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 cadmium.

The links between different doses of chemical and organic fertilizers and cadmium concentration in wheat and maize grains 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

Average concentrations of cadmium in wheat grains in experiment with chemical fertilizers with nitrogen, phosphorus and farmyard manure were 0.056 mg/kg in control variant, 0.059 mg/kg (higher with 6.2% compared to the control) in variant N₅₀P₀ + 20 t/ha farmyard manure, 0.063 mg/kg (higher with 13.4% compared to the control) in the fertilized variant with N₅₀P₅₀ + 40 t/ha farmyard manure, the differences in the two variants are statistically insignificant, 0.067 mg/kg respectively (higher with 20.5% compared to the unfertilized variant) in variant N₁₀₀P₁₀₀ + 60 t/ha farmyard manure, the difference being statistically significant (Table 1).

Table 1

The influence of NP fertilizers and farmyard manure on cadmium concentration in winter wheat grains, average data

Variant	Cd concentration		Difference		Statistical significance
	mg/kg	%	mg/kg	%	
N ₀ P ₀ + 0 t/ha FYM	0.056	100	-	-	Control
N ₅₀ P ₀ + 20 t/ha FYM	0.059	106.2	0.003	6.2	-
N ₅₀ P ₅₀ + 40 t/ha FYM	0.063	113.4	0.007	13.4	-
N ₁₀₀ P ₁₀₀ + 60 t/ha FYM	0.067	120.5	0.011	20.5	*
		LSD 5%	0.009		
		LSD 1%	0.017		
		LSD 0.1%	0.029		

*FYM - farmyard manure

Regarding the mathematical modeling of the obtained data, it shows that the polynomial function, $y = 0.000x^2 + 0.002x + 0.048$, $R^2 = 0.785$ best quantifies the connection between the doses of fertilizers with nitrogen, phosphorus and manure and the concentration of cadmium in wheat grains (Figure 1).

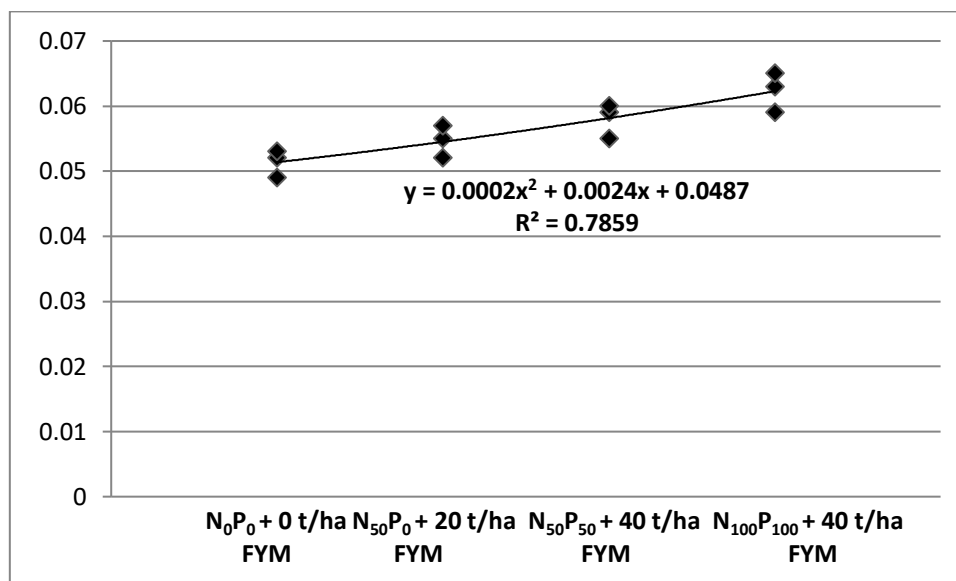


Fig. 1. Correlation between doses of NP fertilizers and farmyard manure and cadmium concentration in wheat grains

The average concentration of cadmium in maize grains in the three years studied, the experiments with chemical fertilizers with nitrogen, phosphorus and farmyard manure was 0.040 mg/kg in control variant, 0.043 mg/kg (higher than 8.4% compared to control one) in variant $N_{50}P_0 + 20$ t/ha farmyard manure, 0.046 mg/kg (16% higher compared to the control variant) in the variant fertilized with $N_{50}P_{50} + 40$ t/ha farmyard manure, statistically insignificant differences, respectively 0.049 mg/kg (23.3% higher compared to unfertilized variant) in variant $N_{100}P_{100} + 60$ t/ha farmyard manure, the difference being statistically significant (Table 2).

Table 2

The influence of NP fertilizers and farmyard manure on cadmium concentration in maize grains, average data

Variant	Cd concentration		Difference		Statistical significance
	mg/kg	%	mg/kg	%	
$N_0P_0 + 0$ t/ha FYM	0.040	100	-	-	Control
$N_{50}P_0 + 20$ t/ha FYM	0.043	108.4	0.003	8,4	-
$N_{50}P_{50} + 40$ t/ha FYM	0.046	116.0	0.006	16,0	-
$N_{100}P_{100} + 60$ t/ha FYM	0.049	123.3	0.009	23,3	*
		LSD 5%	0.009		
		LSD 1%	0.016		
		LSD 0.1%	0.025		

Mathematical modeling of the results of the cadmium concentration in maize grains from the NP and manure experiments studied shows that the exponential function best quantifies the relationship between nitrogen, phosphorus and manure fertilizer doses and the concentration of cadmium from maize grains (Figure 2).

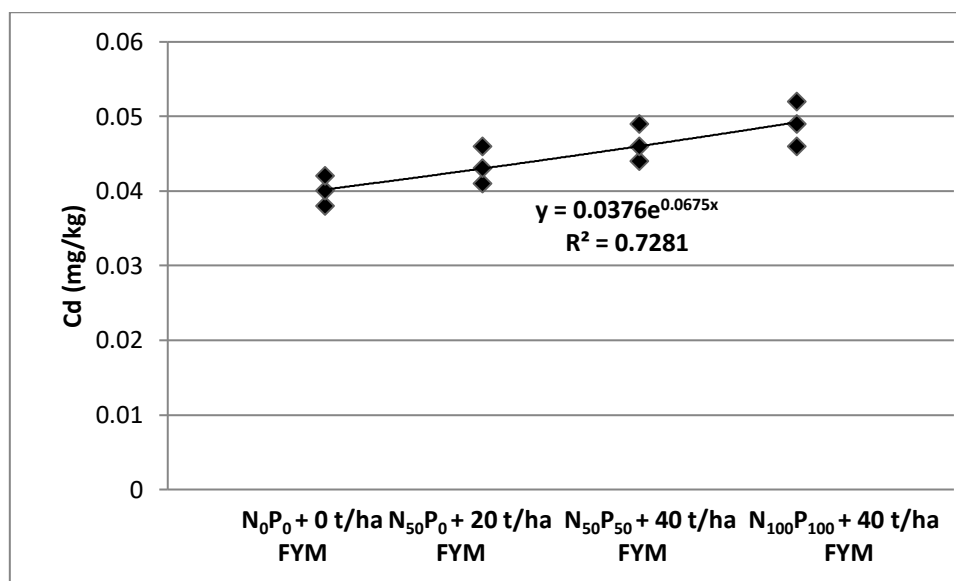


Fig. 2. Correlation between doses of NP fertilizers and manure and cadmium concentration in maize grains

CONCLUSIONS

In all chemical fertilized variants, cadmium concentration from winter wheat and maize grains is far below the permissible limits.

The farmyard manure doses applied led to increases in wheat grains from 0.056 mg/kg in control variant to 0.067 mg/kg in variant N₁₀₀P₁₀₀ + 60 t/ha farmyard manure, the difference being statistically insured, respectively in maize grains, the difference recorded was 23.3% higher (0.049 mg/kg).

By applying manure combined with nitrogen and phosphorus fertilizers, the accumulation of cadmium in wheat and corn seeds is reduced.

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