INFLUENCE OF THE MINERAL AND ORGANIC FERTILIZERS UNDER DE CADMIUM CONCENTRATION OF THE SOIL-PLANT SYSTEM

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Abstract

This research aims to evaluate the impact of applying different doses and combinations of NP fertilizers and farmyard manure in long term trials on the concentration of cadmium in soil and grains (winter wheat and maize) in 2010 – 2012 period.

There were studied four variants: V_1 - N_0P_0 + 0 t/ha farmyard manure (control), V_2 - $N_{50}P_0$ + 20 t/ha farmyard manure, V_3 - $N_{50}P_{50}$ + 40 t/ha farmyard manure, respectively V_4 - $N_{100}P_{100}$ + 60 t/ha farmyard manure.

Fertilization with different doses of NP and farmyard manure did not cause an increase in the concentration of cadmium which exceeds the maximum limits allowed components of soil – plant system. This demonstrates the importance and necessity of using organo-mineral fertilization one to ensure sustainable production performance without negative impact on soil and plant products.

Keywords: organo-mineral fertilization, cadmium, winter wheat, maize

INTRODUCTION

An important source of pollution with heavy metal is agriculture by the inputs used (chemical fertilizers, organic fertilizers, pesticides, irrigation water). The systematic and long application of phosphoric fertilizers and those with zinc leads to the accumulation of cadmium in soils (Ciobanu Gh., 2007, Vuşcan A., 2014)

Metals, in particular heavy metals, can be driven by rainfall in soil's lower layers, where by the bioaccumulation, they reach to plants-animals-human. For these reasons, it was necessary to establish some critical loads of metals whose concentrations should not be exceeded, in order to not be any risk of soil transformation in a potential supplier of environmental pollutants (Irwin R.J. et al, 1997).

When used appropriately, anorganic fertilizers positively influences plant growth, the accumulation of organic matter and the biological activity of soil (Samuel A.D., 2003, 2009), preventing soil's damage and erosion (Domuţa C., 2006, Domuţa C. şi Brejea R., 2010).

Cadmium is in the form of ions (Cd^{2+}) the various compounds of the soil solution, bound to the organic matter existing in soil or is present in clay and minerals from soil (Dudka S. et al, 1994). Translocation of cadmium in soils and the possibility of accumulation in organisms is due to the low

acidity of the soil, the low humus content,the large size of soil particles and the retention capacity of the soil (Florea N. and Ianoş Gh., 2002).

The accessibility of heavy metals for plants is not constant, but vary both depending on the species, and also on the environmental conditions:climate, soil. Lettuce, unlike carrots and potatoes, has a greater capacity to accumulate heavy metals, especially zinc, copper and cadmium, and clover absorbs copper faster than grasses. Tolerance levels of different cultures to heavy metals are in descending order: herbs, grasses, cereals, potatoes and sugar beet (McGrath S.P., 1992, R.L. Hough et al., 2003).

In case of wheat roots the translocation of heavy metals is in the following order: Mn > Ni > Zn > Cd > Co > Cr > Cu > Pb, respectively in the wheat plant the distribution of heavy metal is as follows: Mn > Zn> Pb > Ni > Co > Cd > Cu > Cr (B. Lukšienė and M. Račaitė, 2008).

The concentration of cadmium in wheat and barley depends significantly on mineral fertilization, increasing in the same time with high doses of NPK fertilizers, the grains of barley recording a higher concentration. The application of amendments has not been shown to have significant effect on cadmium concentration, but the trend of cadmium concentration is to decrease (Kaniuczack J. et al, 2011).

The content of some metals (Cd, Cr, Ni and Zn), especially nickel's, significantly reduce the power of emergence of corn and rice (Pandey S.N. et al., 2008). By applying NPK fertilizers, containing phosphorus small doses (22,5-45 kg P_2O_5/ha), in maize culture, it is found that the accumulation of heavy metals is very low: As<2,5; Cd<0,5; Cr<0,5; Pb<2,5 şi Ni<0,5 (Orosz F. et al, 2009).

In case of wheat crop, the application of different doses of NPK, respectively various doses of lead (0 – 20 µg/g) has determined the increasing the concentration of lead in grain and straw without exceeding the maximum admited limit, not having a negative impact on animals and humans (Salwa A.I., 2009).

The purpose of this work is to study the impact of organo-mineral fertilization on cadmium and lead concentration in preluvosoil, winter wheat and maize grains.

MATERIAL AND METHOD

Research data were obtained i n the context of long-term trial located on the preluvosoil from Oradea, using a unique design in all research networks of National Agricultural Research and Development Institute Fundulea.

The natural environment where the research is conducted

From a climate point of view, the research has been conducted in three years totally different in terms of rainfall, in 2010 their amount being 869.0 mm in 2011 was 569.7 mm, and respectively in 2012 were recorded 418.9 mm. The air temperature was almost identical 11.3 °C in 2010 and 2012 and 11.4 °C in 2011. With regard to air humidity, its average was 79% in 2010, 73% in 2011 and 70% in 2012.

Soil reaction on arable horizon is slightly acid. The lack of calcium carbonate in the soil profile is obvious from the data presented. Soil content in mobile aluminum in horizon A can affect the normal growth of some plants. The soil is well supplied with mobile potassium and phosphorus. Humus content in soil is average.

Biological material and research methods used

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

Variants studied

Factor A: farmyard manure doses; a1: unfertized; a2: 20 t/ha farmyard manure; a3: 40 t/ha farmyard manure; a4: 60 t/ha farmyard manure.

Factor B: nitrogen and phosphorus combinations; b1: N_0P_0; b2: $N_{50}P_0$; b3: $N_{50}P_{50}$; b4: $N_{100}P_{100}$

Analytical methods used in determining the heavy metals

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 soil samples to determine the cadmium concentration was done with concentrated strong acids and hydrogen peroxide: HNO_3, HCl and H_2O_2 using the digester MILESTONE.

Mineralization of plant biological material samples to determine the cadmium concentration was done with a mixture of sulfuric and perchloric acids.

Dosage of heavy metal (Cd). For the determination of the cadmium concentration under study, samples of soil and vegetal biological material, prepared according to the working methods presented above were analyzed by spectrophotometer with atomic absorption SHIMADZU AA-6300.

RESULTS AND DISCUSSION

In the control variant the average for the period 2010-2012 of the cadmium concentration in the soil was 1.117 mg/kg. Fertilization $N_{50}P_0$ + 20 t/ha farmyard manure resulted in an increase of 0.121 mg/kg and 10.8%, the difference was statistically insignificant. In the variant $N_{50}P_{50}$ + 40 t/ha farmyard manure the cadmium recorded value of 1.341 mg/kg, higher then 20% compared to the control variant, and fertilization $N_{100}P_{100}$ + 60 t/ha farmyard manure resulted in an increase 31.4%, or 0.350 mg/kg respectively compared to the control variant, the differences are statistically significant (Table 1).

Table 1

The influence of NP fertilizers and farmyard manure on cadmium concentration in preluvosoil from long term trial, average data (Oradea, 2010-2012)

Variant	Cd concentration		Difference		Statistical significance
	mg/kg	%	mg/kg	%	
N_0P_0 + 0 t/ha FYM	1,117	100	-	-	Control
$N_{50}P_0$ + 20 t/ha FYM	1,238	110,8	0,121	10,8	-
$N_{50}P_{50}$ + 40 t/ha FYM	1,341	120,0	0,223	20,0	*
$N_{100}P_{100}$ + 60 t/ha FYM	1,468	131,4	0,350	31,4	*
		LSD 5%	0,166		
		LSD 1%	0,379		
		LSD 0,1%	0,633		

Of the five types of test functions (exponential, linear, logarithmic, polynomial, power) polynomial function is best statistically the cadmium concentration in the soil of the 4 variants studied, $y = 0.001x^2 + 0.107x + 1.010$, $R^2 = 0.99$. (Figure 1)

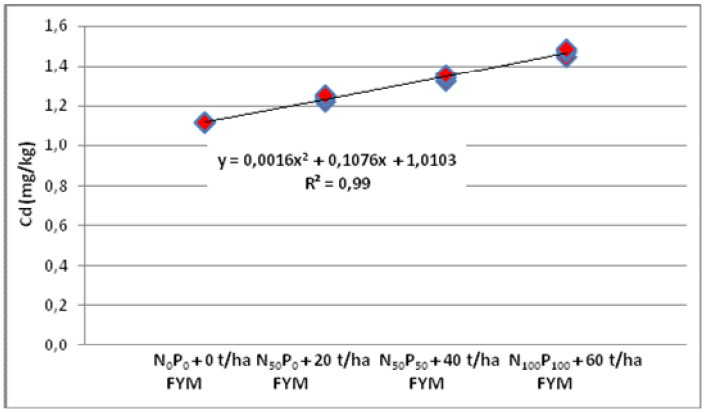

Figure 1. Correlation between doses of NP fertilizers and farmyard manure and cadmium concentration in soil, Oradea 2010-2012

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 $N_{50}P_0$ + 20 t/ha farmyard manure, 0.063 mg/kg (higher with 13.4% compared to the control) in the fertilized variant with $N_{50}P_{50}$ + 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 $N_{100}P_{100}$ + 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 winter wheat grains, average data (Oradea, 2010-2012)

Variant	Cd concentration		Difference		Statistical significance
	mg/kg	%	mg/kg	%	
N_0P_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		

Regarding the mathematical modeling of data obtained show that polynomial type function, $y = 0.000x^2 + 0.002x + 0.048$, $R^2 = 0.785$ best quantified the relationship between doses of nitrogen fertilizer, phosphorus and farmyard manure and cadmium concentration wheat grains (Figure 2).

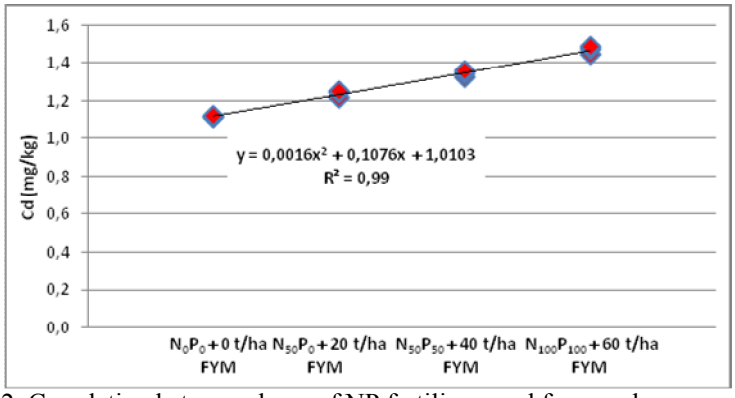

Figure 2. Correlation between doses of NP fertilizers and farmyard manure and cadmium concentration in winter wheat grains, Oradea 2010-2012

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 3).

Table 3

The influence of NP fertilizers and farmyard manure on cadmium concentration in maize grains, average data (Oradea, 2010-2012)

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 on the cadmium concentration in maize variants of experience with NP and farmyard manure studied shows that the exponential function type is best quantified the relationship between doses of nitrogen and phosphorus fertilizer and farmyard manure and cadmium concentration in maize grains (Figure 3).

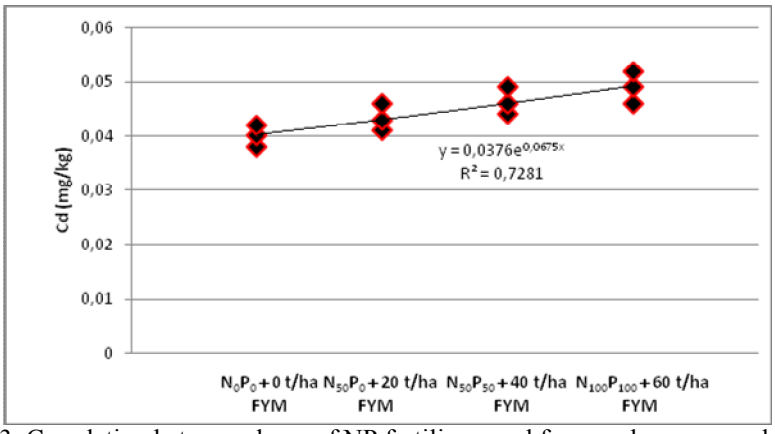

Figure 3. Correlation between doses of NP fertilizers and farmyard manure and cadmium concentration in maize grains, Oradea 2010-2012

CONCLUSIONS

The researches performed during 2010-2012 in long term trial with NP fertilizers and farmyard manure, regarding the influence of organo-

mineral fertilization on cadmium concentration from soil, winter wheat and maize grains, led to the next conclusions:

The concentration of cadmium in preluvosoil from long long term trial with NP doses and farmyard manure is influenced by the dose of fertilizer used.

The increase of farmyard manure doses determined an increase of the cadmium concentration at 1.468 mg/kg in variant $N_{100}P_{100}$ + 60 t/ha farmyard manure, but the relative differences from the control, N_0P_0 + 0 t/ha farmyard manure, (1.117 mg/kg).

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 $N_{100}P_{100}$ + 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).

Application of farmyard manure leads to cadmium inhibition in the soil-plant system.

The concentration of cadmium in soil and plant (wheat and maize grains) is below the maximum limits allowed by current standards.

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