

Study regarding the influence of the NPK fertilizers use in long term trial on heavy metals concentration in wheat grains

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SUMMARY

The paper presents research results obtained in stationary experiments, carried out at Agricultural Research and Development Station Oradea, regarding the influence of nitrogen, phosphorus and potassium fertilizers, on Cd, Pb, Cu, Zn and Ni concentration on wheat grains.

The minimum concentration of cadmium in wheat grains was recorded in the case of the unfertilized plot $N_0P_0K_0$, 0.12 mg kg^{-1} , and maximum value 0.22 mg kg^{-1} , was registered at the fertilized plot with $N_{160}P_{80}K_{120}$, relative difference relative to control was 84.2%.

Lead concentration had the lowest value in the unfertilized plot, the value (0.4 mg kg^{-1}) being under the maximum allowed (1.0 mg kg^{-1}). In case of the fertilized plot with $N_{160}P_{80}K_{120}$, the lead concentration had the highest value, 0.47 mg kg^{-1} , but even in this case it was located beneath the maximum limit allowed.

In all four systems of fertilization, copper has not exceeded the maximum allowed limit (5 mg kg^{-1}), the values have been comprised between 1.68 mg kg^{-1} at the unfertilized plot and 2.81 mg kg^{-1} at the fertilized plot with $N_{160}P_{80}K_{120}$. In other plots of fertilization copper had concentrations of 1.97 mg kg^{-1} , at the fertilized plot with $N_{80}P_{40}K_{40}$, and 2.78 at the fertilized plot with $N_{80}P_{80}K_{80}$.

The lowest concentration of zinc, 26.47 mg kg^{-1} , has been registered in the control $N_0P_0K_0$. In the other fertilization plots studied, the zinc concentrations had the following values: 27.66 mg kg^{-1} ($N_{80}P_{40}K_{40}$), ($N_{80}P_{80}K_{80}$) 29.87 mg kg^{-1} and 33.62 mg kg^{-1} ($N_{160}P_{80}K_{120}$).

Nickel has registered the lowest value in the unfertilized plot, 3.47 mg kg^{-1} . The fertilized plot with $N_{160}P_{80}K_{120}$ had the highest value 4.94 mg kg^{-1} , with 42.39% higher compared to the control $N_0P_0K_0$.

Keywords: NPK fertilizers, doses, long term trial, heavy metals, wheat grains

INTRODUCTION

The environment was contaminated with heavy metals since the time of the original magma of the Earth began to solidify. Excessive concentrations of heavy metals in the soil, without human impact, are the result of natural nitrogen mineralisation (Turner, 1994).

By comparing the amount of heavy metals from naturally and those arising from human activities, Ross (1994) shows that human activities are delivering 13 times more Cu and 21 times more Zn, than natural processes (Răducu et al., 2012).

In food, the metals with toxic potential come in different ways: with the raw materials as a result of the treatments applied in agriculture, during processing, storage and transportation, from auxiliary materials and from the water used during technological processes, as a result of corrosion processes.

It has been demonstrated that the tolerance of corn, wheat, clover, soybean and sunflower plants to Pb uptake were differed, the highest concentration of Pb were determined in corn, clover and soybean and the lowest in sunflower and wheat (El-Aziz et al., 2009).

Orosz et al. (2009), demonstrates that the application of chemical fertilizers with nitrogen, phosphorus and potassium in moderate doses does not lead to significant increases of heavy metals concentrations in grain.

The preluvo soil from Oradea, Romania, is a medium provide with the main nutritive elements, with a weak acid reaction in the ploughing horizon (Ciobanu, 2007; Vușcan et al., 2010). Many researches on preluvo soil (Samuel et al., 2008; Domuța, 2009) have shown the negative effect of long-term application of nitrogen, as ammonium nitrate, on soil reaction.

The factors which have a negative influence on heavy metals concentration are high level soil content

in the H^+ and Al^{3+} , Fe^{2+} and Mn^{2+} and low level soil content in main nutrients, low activity of microorganisms (Samuel, 2009), and stagnation of water because of unsatisfactory infiltration (Șandor et al., 2008; Brejea, 2010).

This paper has proposed to present the results regarding the influence of nitrogen, phosphorus and potassium fertilizers applied in long term field experiments on Cd, Pb, Cu, Zn and Ni concentrations in wheat yield.

MATERIAL AND METHOD

The research data was obtained at the Agricultural Research and Development Station Oradea, using a unique design in all research networks of National Agricultural Research and Development Institute Fundulea.

The investigation has been carried out beginning with the autumn of 1974 in Oradea, in a flat plain area on the third terrace of the Crisul Repede River.

Field experiment with potassium fertilizers was set up in 1974 using a crop rotation: pea – winter wheat – maize – sunflower.

The factors researched were the potassium and NP rates applied:

- potassium rate : K_0 , K_{40} , K_{80} , K_{120}
- NP rates: N_0P_0 ; $N_{80}P_{40}$; $N_{80}P_{80}$; $N_{160}P_{80}$. (N was applied like ammonium nitrate, in spring, P was applied like superphosphate and K like KCl in autumn).

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

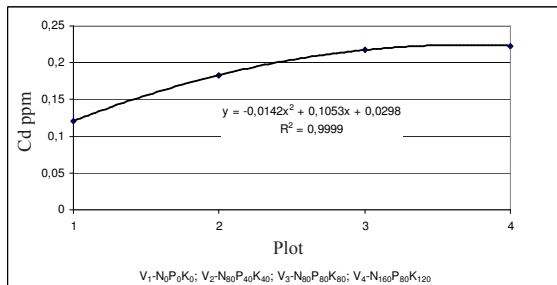
Grain concentration of heavy metals was determined using the mineralization with sulphuric and perchloric acid mixture method. The results were determined by using the atomic absorption spectrophotometer.

RESULTS AND DISCUSSION

Influence of NPK fertilizers on cadmium concentration in wheat

In case of $N_0P_0K_0$ plot, concentration of cadmium had the 0.12 mg kg^{-1} value. In the case of the plot fertilized with $N_{80}P_{40}K_{40}$ the value of cadmium concentration was 0.18 mg kg^{-1} , noticing that the concentration of cadmium increases with 0.06 mg kg^{-1} , respectively with 51.2% compared to unfertilized plot. The concentration of cadmium has the 0.21 mg kg^{-1} value at the fertilized plot with $N_{80}P_{80}K_{80}$ with 0.09 mg kg^{-1} , respectively 80.1% compared to $N_0P_0K_0$ plot. Wheat seeds from the fertilized plot with $N_{160}P_{80}K_{120}$ had a cadmium concentration of 0.22 mg kg^{-1} , with 0.10 mg kg^{-1} (84.2%) higher than the control plot (figure 1).

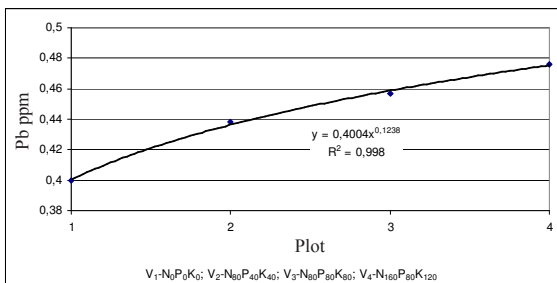
Figure 1: Influence of NPK fertilizers on cadmium concentration in wheat cultivated in long term trial from Oradea (2010–2012)



Influence of NPK fertilizers on lead concentration in wheat

The lead concentration in $N_0P_0K_0$ plot had 0.40 mg kg^{-1} value. In the fertilized plot with $N_{80}P_{40}K_{40}$, lead had 0.43 mg kg^{-1} concentration, with 0.03 mg kg^{-1} , respectively 9.5% higher compared to the control plot. In case of the plot fertilized with $N_{80}P_{80}K_{80}$, the lead concentration had 0.45 mg kg^{-1} value, with 0.05 mg kg^{-1} , respectively 14.2% higher than in case of the control plot. In case of the plot fertilized with $N_{160}P_{80}K_{120}$, lead concentration had a value of 0.47 mg kg^{-1} , with 0.07 mg kg^{-1} respectively with 19% higher than the unfertilized plot (figure 2).

Figure 2: Influence of NPK fertilizers on lead concentration in wheat cultivated in long term trial from Oradea (2010–2012)

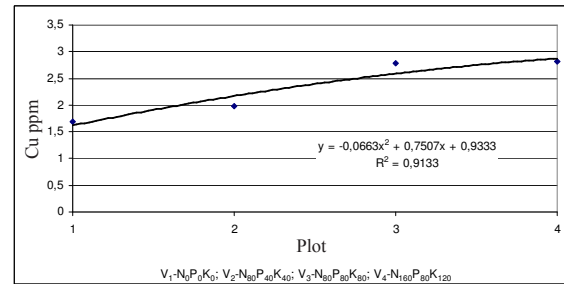


Influence of NPK fertilizers on copper concentration in wheat

The analysed samples from the $N_0P_0K_0$ plot had 1.68 mg kg^{-1} copper concentration, and from the fertilized plot with $N_{80}P_{40}K_{40}$ had 1.97 mg kg^{-1} value, with

0.29 mg kg^{-1} , respectively 17.29% higher. In case of the fertilized plot with $N_{80}P_{80}K_{80}$, the copper concentration had 2.78 mg kg^{-1} value, with 1.10 mg kg^{-1} , respectively 65.48% higher than the unfertilized plot. Copper had a concentration of 2.81 mg kg^{-1} in the fertilized plot with $N_{160}P_{80}K_{120}$, with 1.13 mg kg^{-1} , respectively 67.02% higher than the $N_0P_0K_0$ plot (figure 3).

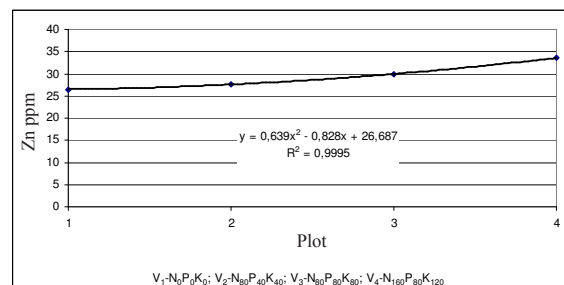
Figure 3: Influence of NPK fertilizers on copper concentration in wheat cultivated in long term trial from Oradea (2010–2012)



Influence of NPK fertilizers on zinc concentration in wheat

$N_0P_0K_0$ plot had 26.47 mg kg^{-1} zinc concentration. In case of the fertilized plot with $N_{80}P_{40}K_{40}$, the zinc had 27.66 mg kg^{-1} concentration value, with 1.20 mg kg^{-1} , respectively 4.50% higher than the $N_0P_0K_0$ plot. In case of the plot fertilized with $N_{80}P_{80}K_{80}$, the zinc concentration value was 29.87 mg kg^{-1} with 3.40 mg kg^{-1} , respectively 12.84% higher than the $N_0P_0K_0$ plot. The value of zinc concentration in the $N_{160}P_{80}K_{120}$ fertilized plot was 33.62 mg kg^{-1} , with 7.16 mg kg^{-1} respectively 27.01% higher than the control plot (figure 4).

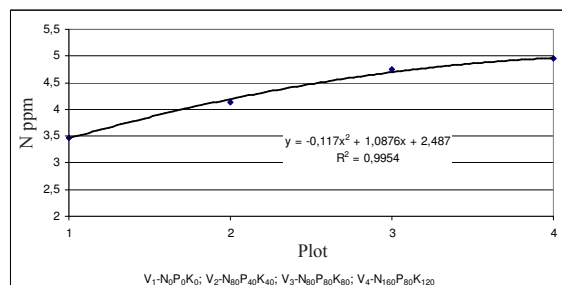
Figure 4: Influence of NPK fertilizers on zinc concentration in wheat cultivated in long term trial from Oradea (2010–2012)



Influence of NPK fertilizers on nickel concentration in wheat

Nickel concentration at the $N_0P_0K_0$ plot had 3.47 mg kg^{-1} value. In case of the plot fertilized with $N_{80}P_{40}K_{40}$, the value of nickel concentration was 4.14 mg kg^{-1} , noting that, nickel concentration increases with 0.67 mg kg^{-1} , respectively 19.19%, compared to the $N_0P_0K_0$ plot. The plot fertilized with $N_{80}P_{80}K_{80}$ had 4.74 mg kg^{-1} value of nickel concentration, with 1.27 mg kg^{-1} , respectively 36.66% than the $N_0P_0K_0$ plot. Wheat seeds from the plot fertilized with $N_{160}P_{80}K_{120}$ had 4.94 mg kg^{-1} concentration of nickel, with 1.47 mg kg^{-1} (42.39%) higher than the $N_0P_0K_0$ plot (figure 5).

Figure 5: Influence of NPK fertilizers on nickel concentration in wheat cultivated in long term trial from Oradea (2010–2012)



CONCLUSIONS

Researches carried out during 2010–2012 in a long term experience with doses and combinations of N, P, K located in 1974 to Agricultural Research and Development Station Oradea, have led to the following conclusions on the concentration of heavy metals in wheat grains.

The minimum concentration of cadmium in wheat grains was recorded in the case of the unfertilized plot $N_0P_0K_0$, 0.12 mg kg^{-1} , and maximum value 0.22 mg kg^{-1} , was registered at the fertilized plot with $N_{160}P_{80}K_{120}$; relative difference to control was 84.2%.

Lead concentration had the lowest value in the unfertilized plot, the value (0.4 mg kg^{-1}) being under the maximum allowed (1.0 mg kg^{-1}). In case of the fertilized plot with $N_{160}P_{80}K_{120}$, the lead concentration had the highest value, 0.47 mg kg^{-1} , but even in this case it was located beneath the maximum limit allowed.

In all four systems of fertilization, copper did not exceed the maximum allowed limit (5 mg kg^{-1}), the values have been comprised between 1.68 mg kg^{-1} at the unfertilized plot and 2.81 mg kg^{-1} at the fertilized plot with $N_{160}P_{80}K_{120}$. In other plots of fertilization copper had concentrations of 1.97 mg kg^{-1} , at the fertilized plot with $N_{80}P_{40}K_{40}$, and 2.78 at the fertilized plot with $N_{80}P_{80}K_{80}$.

The lowest concentration of zinc, 26.47 mg kg^{-1} , has been registered in the control $N_0P_0K_0$. In the other fertilization plots studied, the zinc concentrations had the following values: 27.66 mg kg^{-1} ($N_{80}P_{40}K_{40}$), ($N_{80}P_{80}K_{80}$) 29.87 mg kg^{-1} and 33.62 mg kg^{-1} ($N_{160}P_{80}K_{120}$).

Nickel reached the lowest value in the unfertilized plot, 3.47 mg kg^{-1} . The fertilized plot with $N_{160}P_{80}K_{120}$ had the highest value 4.94 mg kg^{-1} , with 42.39% higher compared to the control $N_0P_0K_0$.

Our researches highlight that increasing doses of fertilizer, especially those with phosphorus, leads also to the increase of heavy metals concentration.

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