CHANGES OF SOIL MICROELEMENTS CONTENT AFTER INTESIVE MINERAL FERTILIZATION

MODIFICAREA CONTINUTULUI DE MICROELEMENTE DIN SOL IN URMA FERTILIZARII MINERALE INTENSIVE

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Abstract: *In this study contents of selected microelements were determined in cambic chernozem after intensive mineral fertilization. The studies presented in this paper concern 4 years of experiments. Soil content in Fe, Mn and Zn were determined, in the 0-20cm depth, by DTPA + ammonium bicarbonate method. Boron content of soil was also determined through HCl method. Modification of microelements content in soil resulted from intensive nitrogen fertilizers application, on different pre – fertilized plots with phosphorus and potassium, and decrease of soil pH. Soil microelements content was considered medium in all experimental plots, with exception of Zn in plots with high doses of phosphorus fertilizers.*

Rezumat: *In lucrare sunt prezentate rezultatele cercetarilor privind influenta fertilizarii minerale intensive asupra continutului in unele microelemente a cernoziomului cambic. Experientele s-au desfasurat pe o perioada de 4 ani. A fost determinat continutul solului in Fe, Mn si Zn pe adancimea 0 – 20 cm, prin metoda cu DTPA + carbonat de amoniu.Continutul solului in B a fost determinat prin metoda cu HCl. Modificarea continutului solului in microelemente este determinata de aplicarea intensiva a ingrasamintelor cu azot, pe diferite agrofonduri cu fosfor si potasiu, precum si de modificarea pH – ului solului. Continutul solului in microelemente este mediu in toate variantele experimentale, cu exceptia Zn in variantele fertilizate cu doze ridicate de fosfor.*

Key words: *mineral fertilization, soil, microelements*
Cuvinte cheie: *fertilizare minerala, sol, microelemente*

INTRODUCTION

Plants require water, air, light, suitable temperature and 16 nutrients to grow. Plants absorb carbon, hydrogen and oxygen from air and water. The other 14 nutrients come from the growing medium – soil.

Soil nutrients are divided into two groups according to their demanded quantity by the plants. The macronutrients are those that are demanded in relatively high levels. In the group of microelements we can distinguish: nitrogen (N), phosphorus (P), potassium (K), Calcium (Ca), magnesium (Mg) and sulphur (S). The micronutrients, which are only needed in trace amounts, are iron (Fe), manganese (Mn), boron (B), zinc (Zn), copper (Cu), molybdenum (Mo) and chloride (Cl).

The importance of microelements in plant nutrition is high and they should not be neglected although they are needed in minor quantities. Any deficiency of a nutrient, no matter how small the amount needed, it will hold back plant development (MULDER, J., CRESSER M.S, 1994).

In soils, iron is weathered from minerals and appears as divalent cation in soil solution. It can react with hydroxil ion (HO^-) to be converted to insoluble form, which is unavailable. It can appear in toxic concentration in acid soil but deficiencies are common in alkali soils. This is because the formation of hydroxides and oxide forms of Fe^{2+} are insoluble

[$Fe(OH)_2$, FeO_2 or Fe_2O_3]. Since Fe^{2+} is a precursor to synthesis of chlorophyll deficiency develops pathological chlorosis in plant. Deficiency symptoms are commonly found in plants growing in calcareuos alkaline soils. Iron chlorosis can be induced by K^+ deficiency or excess application of phosphate.

Manganese is also derived from weathered minerals in soils and also appears as divalent ion. Its availability increases with decreasing pH. Cereals and grasses including sugar cane tend to have mn deficiency in alkaline soils (BOHN H.L, 2001).

In soils, zinc is available in the following three categories: fixed forms (fixed and found in soil minerals), moderately available (depends on the pH of the soil and also its organic matter content), insoluble form (Zn hydroxide occurs in soils as a result of liming when yhe pH is increased). Zinc deficiencies are common in calcareous soils where high pH reduces Zn – availability or in acid sand where Zn has been leached from the soil. Organic soils are also low in Zn reserves and plants are commonly deficient. In some cases, Zn deficiency is caused by high phosphate fertilization.

Most of the boron in soil is the form of highly insoluble mineral. It is released in mineral weathering as borate. It is rapidly changed to slowly available in alkaline pH and becomes less available in highly alkaline pH. The retention of boron is least in acid soils. Boron accumulates in soil organic material. Boron toxicity can be alleviated by increasing concentrations of calcium.

MATERIAL AND METHOD

The researches have been made on soil intensively fertilized with mineral fertilizers without micronutrients. Soil type was the cambic chernozem with middle texture from Didactic Station Timisoara, with following properties:

-total density ranged between 2.43 g|cmc and 2.58 g|cmc, lower in higher;

-total porosity has medium values, excepting the soil surface were total porosity has highest value: 47%;

-soil reaction is weakly acid, pH=6.18;

-humus content of soil is ranged between 3.28 si 2.10%, nitrogen indicator is ranged between 3.08 la 2.04;

-phosphorus soil content is low – 15.1 ppm, and potassium content of soil is medium– 184 ppm;

-the value of cationic exchange capacity of soil is 30.35 me/100g.

Intensive mineral fertilization was made on winter wheat. The experiments were of bifactorial type, with 5 variants and 4 repetitions, as it follows:

Factor 1. Nitrogen fertilization

1 - N_0 (0 kg/ha)
2 – N_{50} (50 kg/ha)
3 – N_{100} (100 kg/ha)
4 – N_{150} (150 kg/ha)
5 – N_{200} (200 kg/ha)

Factor 2. Phosphorus and potassium fertilization

1. – P_0K_0 (0 kg/ha)
2. - $P_{50}K_{50}$ (50 kg/ha)
3. – $P_{100}K_{100}$ (100 kg/ha)
4. – $P_{150}K_{150}$ (150 kg/ha)

In order to fertilize the plots, it has been used complex fertilizers NPK15:15:15 and ammonium nitrate (33.5%N).

From field experiment soil samples was taken by depth of 0-20 cm for testing after cropping. Soil analysis was made in Soil Science and Plant Nutrition Laboratory from Agriculture Faculty of Timisoara.

Iron, manganese and zinc content of soil were determined with DTPA + ammonium bicarbonate method. Fe, Zn and Mn content was measured directly in the filtrate by an Atomic Absorption Spectrophotometer Varian 220. Boron was determined by HCl method, its content was read by UV – VIS spectrophotometer Cintra 400 at 420 nm wavelength.

pH was determined in water extract (soil: water = 1:2.5). Phosphorus soil content was determined by extraction with ammonium acetate – lactate solution. P content was read on the spectrophotometer Cintra 400, at wave length of 660 nm.

RESULTS AND DISCUSSIONS

After long term fertilization with mineral fertilizers which contain exclusively N,P,K, soil content in micronutrients determined by analysis is presented in table 1:

Table 1

Micronutrients content of soil after intensive mineral fertilization (ppm)

Variant		Fe	Mn	Zn	B
P_0K_0	N_0	1,96	1,18	1,40	0,645
	N_{50}	1,98	1,22	1,65	0,665
	N_{100}	2,10	1,25	2,10	0,625
	N_{150}	2,15	1,28	2,05	0,685
	N_{200}	2,18	1,31	1,80	0,685
$P_{50}K_{50}$	N_{50}	1,99	1,16	1,45	0,675
	N_{100}	2,06	1,19	1,62	0,615
	N_{150}	2,09	1,20	2,00	0,635
	N_{200}	2,15	1,27	1,85	0,660
$P_{100}K_{100}$	N_{100}	2,04	1,15	1,43	0,625
	N_{150}	2,03	1,19	1,80	0,645
	N_{200}	2,06	1,23	1,70	0,675
$P_{150}K_{150}$	N_{150}	1,95	1,15	1,45	0,650
	N_{200}	1,93	1,18	1,30	0,670

Iron content of cambic chernozem from Timisoara is ranged between 1,93 – 2,15 ppm which means a medium soil supply in this micronutrient. A rise of soil iron content is observed as nitrogen fertilizer dose rises. Fertilization with high phosphorus and potassium doses (100 and 150 kg P_2O_5 and K_2O ha^{-1}) determines decrease of iron content of soil and could induce iron deficiency.

Among the different factors affecting the availability of microelements, soil solution pH is the major one. As is shown in table 2, soil solution pH value in control plot is 6,18 and decreases as the nitrogen doses rises, due to his application as ammonium nitrate. Although acid pH values increases iron accessibility in soil (fig.1), excessive supply of phosphorus inactivates iron. Explanations are not fully clear and relate to possible competition of P for Fe with the roots, iron phosphate precipitate on or in the roots.

Manganese content values are ranged between 1,15 ppm, in plot fertilized with 150 kg N, P and K ha^{-1} and 1.27 ppm, in plot fertilized with 200 kg N ha^{-1} and 50 kg P_2O_5 and K_2O ha^{-1}, which corresponds to medium manganese supply of soil.

Manganese content rises on plots pre – fertilized with phosphorus and potassium as the nitrogen doses rises. At the same level of nitrogen fertilization, manganese content of soil decreases as the phosphorus and potassium fertilizer dose increase. Manganese deficiency may occur on soil with low nitrogen content, in drought and on compact soils. High manganese level in soil could determine iron deficiency.

Table 2

Soil pH and phosphorus values after intensive mineral fertilization

Variant		pH	P ppm
P_0K_0	N_0	6,18	15,1
	N_{50}	6,10	16,8
	N_{100}	6,02	17,2
	N_{150}	5,90	17,0
	N_{200}	5,79	17,5
$P_{50}K_{50}$	N_{50}	6,15	17,3
	N_{100}	6,10	18,3
	N_{150}	5,95	18,5
	N_{200}	5,75	18,8
$P_{100}K_{100}$	N_{100}	6,21	18,9
	N_{150}	5,98	20,1
	N_{200}	5,75	20,6
$P_{150}K_{150}$	N_{150}	5,98	20,7
	N_{200}	5,70	21,8

As manganese accessibility for plants concerning, its soil content significantly depends on soil solution reaction. Soil manganese becomes more soluble as the soil pH is lower. We determined a rise of soil manganese content as nitrogen fertilizer dose rises, which applied without phosphorus and potassium leads to soil acidification.

Figure 1 shows the increase of soil manganese content as soil solution pH values decreases. Manganese toxicity appears only on soils with pH lower than 5.5, when Mn^{2+} mobility is highest.

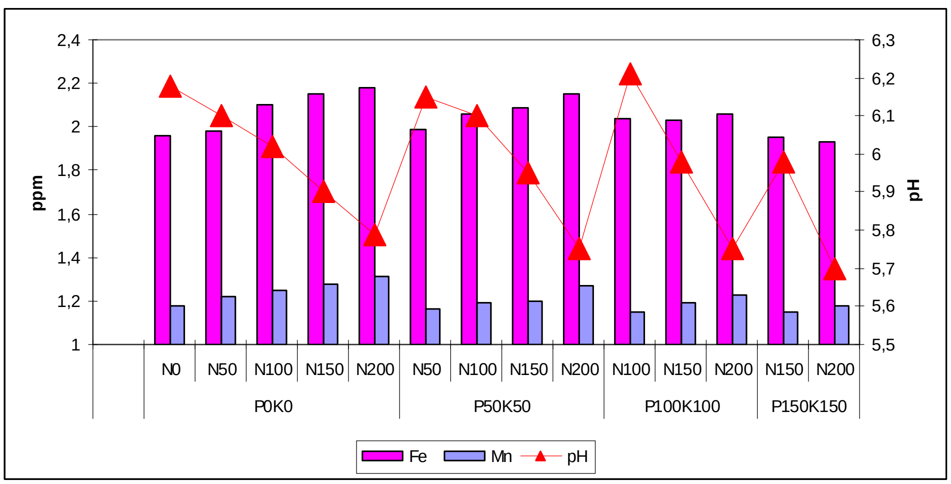

Figure1. Soil solution pH influence upon Fe and Mn soil content b after intensive mineral fertilization

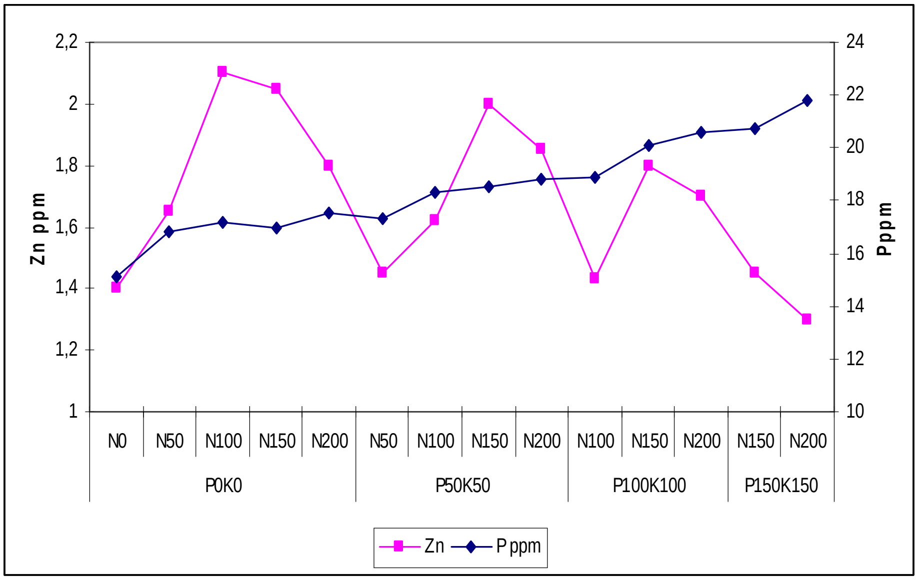

Figure 2. Dependence between phosphorus and zinc content of soil on different fertilization plots

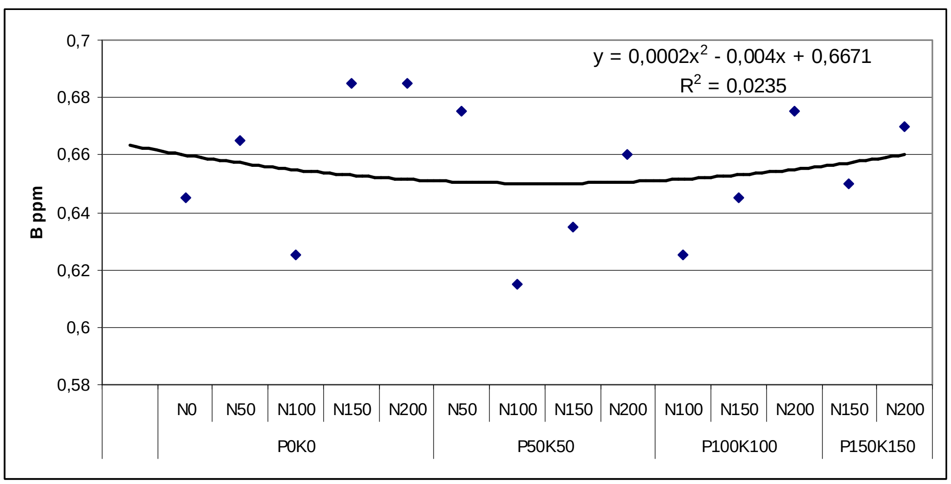

Figure 3. Intensive mineral fertilization influence upon boron soil content

Zinc content values determined with EDTA + ammonium carbonate method are ranged between 1.30 ppm and 2.10 ppm. At the same level of phosphorus and potassium fertilization application of high nitrogen doses (150 and 200 kg N ha^{-1}) leads to decrease of zinc soil content. High levels of nitrogen may induce zinc deficiency because of change in soil solution pH due to nitrogen application. Also zinc retention in the roots as N –Zn protein may occur. Phosphorus and potassium application in larger doses determines decrease of soil zinc content.

As it shown in table 2 soil phosphorus content increases as phosphorus dose rises and P – Zn interaction may occur in soil. As a result formation of Zn – phosphates take place and available zinc content decreases. The lowest Zn value in soil (1.30 ppm) is determined in plots pre – fertilized with highest phosphorus and potassium dose 150 kg P_2O_5 and K_2O ha^{-1}.

After mineral fertilization boron content of soil is ranged between 0.615 ppm, in plots fertilized with $N_{100}P_{50}K_{50}$ and 0.685 ppm, in plots $N_{150}P_0K_0$ and $N_{200}P_0K_0$, which means a medium boron soil supply. Mineral fertilization with nitrogen, phosphorus and potassium does not influence in large extend boron content of soil (fig.3), correlation coefficient being only 0.0235. Differences between boron values in different experimental plots are very low.

CONCLUSIONS

1. After intensive mineral fertilization with nitrogen, phosphorus and potassium soil microelement content is medium, with one exception, Zn, in plots fertilized with high phosphorus doses were Zn content of soil is low.

2. Modification of microelements content in soil resulted from intensive nitrogen fertilizers application, on different pre – fertilized plots with phosphorus and potassium, and modification of soil solution pH.

3. Phosphorus fertilizer applied in large doses decreases soil content in Fe, Mn and Zn.

4. Mineral fertilization with nitrogen, phosphorus and potassium does not influence in large extend boron content of soil

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