INTERRELATION BETWEEN METAL AVAILABILITY, SOIL pH AND MINERAL FERTILIZATION

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Abstract: ***s****olubility and availability metals in soil are directly related with soil pH, Fe and Mn oxidesand NOM. Many scientific studies have generated a large body of information on benefits and environmental impacts associated with land application of mineral fertilizers. For improving soil fertility, in Romania is widely used mineral fertilization (NPK). Due to its influence on soil chemical properties, especially soil reaction which represents the pre eminent factor controlling the chemical behavior of metals and other important processes in soil, the aim of this paper is to establish some relation between these factors. Field trials with the following fertilization variants: $N_0P_0K_0$, $N_{100}P_0K_0$, $N_{200}P_0K_0$, $N_{100}P_{50}K_{50}$, $N_{200}P_{50}K_{50}$, $N_{100}P_{100}K_{100}$, $N_{200}P_{100}K_{100}$, $N_{100}P_{150}K_{150}$, $N_{200}P_{150}K_{150}$ were placed in S.D. Timisoara, on a cambic chernozem soil. Soil type is cambic chernozem with following features:total density ranged between 2.43 g|cmc and 2.58 g|cmc, lower and 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%, nitroge content is ranged between 3.08 la 2.04; phosphorus soil content is low – 13.0 ppm, and potassium content of soil is medium– 184 ppm;the value of cationic exchange capacity of soil is 30.35 me/100g. Soil samples, in three replicates for each variant were analyzed in order to determine soil pH by potentiometric method (water extraction, 1:2.5 ratio) and available metals content (Acetate - EDTA mixture extraction followed by FAAS determination). The results suggested that is a very close dependence between the level of mineral fertilization applied and soil metal availability. The increase of nitrogen doses usually leads to available metal content increasing, due to pH decrease. On the other side P and K fertilization limit the action of nitrogen fertilization on pH, but at high doses, the available metals content decrease, because of low solubility phosphate-metal compounds formed in these conditions. It is very important to know the limits, in order to avoid soil properties depletion, deficiency or excess, soil pollution and, not at least yield quality diminishing.*

Key words**:** *mineral fertilization, soil reaction, metal availability.*

INTRODUCTION

The soil is a key component of terrestrial ecosystems, both natural and agricultural, being essential for the growth of plants and the degradation and recycling of biomass. It is a complex heterogeneous medium comprising mineral and organic solids, aqueous and gaseous components. The minerals present are usually weathering (chemical decomposing) rock fragments and secondary minerals, such as phyllo – silicates or clay minerals, oxides of Fe, Al and Mn and sometimes carbonates ($CaCO_3$). The organic matter comprises living organisms, dead plants material and colloidal humus. These solid components are usually clustered together in the form of aggregates, and have the ability to absorb ions, but this differs between materials and is strongly influenced by the prevailing pH, redox condition and the level of the ions present in soil solution.

In order to improve soil fertility, mineral fertilization is a common practice. In Romania, the most used is NPK fertilization, at different levels. Nitrogen is the nutrient needed in largest quantities by plants, and one of the most frequently applied fertilizer. Application rates are critical, because too little or too much directly impacts crop growth and indirect affect soil properties: pH, nitrates and nitrites content, metal availability. Excessive phosphorus fertilizers can determine or aggravate iron and zinc deficiency and increase soil salt content, due to precipitation of iron and zinc phosphates.

From total content of metals present normally in soil, only a small part is available. The mobility and availability of metals are control by many chemical and biochemical processes such as: adsorption – desorption, complexation – dissociation, and oxidation – reduction. Not all these processes are equally important for each element, but all these processes are affected by soil pH, also influenced by mineral fertilization (ZHENLI L. HE, 2005), (STOFFELLA, 2005).

For available metal determination we used EDTA extraction, because EDTA is a powerful chelating agent, used extensively in soil science to determine bioavailability of metals.

MATERIAL AND METHODS

Field trials with the following fertilization doses: $N_0P_0K_0$, $N_{100}P_0K_0$, $N_{200}P_0K_0$, $N_{100}P_{50}K_{50}$, $N_{200}P_{50}K_{50}$, $N_{100}P_{100}K_{100}$, $N_{200}P_{100}K_{100}$, $N_{100}P_{150}K_{150}$, $N_{200}P_{150}K_{150}$ were placed in S.D. Timisoara, on a cambic chernozem soil. Soil samples, in three replicates for each variant, were air dried at room temperature, ground and sieved through a 2 mm sieve. For each sample we determined pH (water extraction, 1:2,5 ratio) by potentiometric method on a Mettler Toledo pH-meter. Metal available content was determinate by Acetate-EDTA mixture (pH 4.65) extraction (soil:solln = 1:5) (MALAK , 2007). Extracts were filtered and then atomized in flame on a Varian Spectra AA220 FAAS spectrophotometer with an air – acetylene flame, in order to determine the available content of Fe, Zn, Mn, Cu, Ni, on a hallow cathode lamp having resonance lines at 248.3; 213.9; 279.6; 324.8; 232.0 nm.

RESULTS AND DISCUSSIONS

The dependence between NPK levels and soil pH and available Fe, Zn, Mn, Cu, Ni are present in Fig.1.

Available iron content vary in range 38.3 ÷ 64 ($mg \cdot kg^{-1}$). With increase of N dose, we observed the increase of available Fe, due to soil acidification. Also, increasing P and K doses, available Fe content increase too, but not in case of $N_{200}P_{150}K_{150}$ and $N_{100}P_{150}K_{150}$ variant where we considered that low solubility iron-phosphate compounds were formed.

Zinc deficiency is a very important problem in the world's soils. Available zinc concentration could be deficient level because of soil pH, lime content, organic matter amount. Also the amount of applied P fertilizer affects the available zinc concentration in soil (ADILOGLU, 2006; MARSCHNER, 1995). High levels of phosphate in soil can strongly reduce zinc availability due to insoluble phosphates formation. Available zinc content ranged between 7.1 and 19.95 $mg \cdot kg^{-1}$. Maximum values were determined at high doses of nitrogen fertilizer (N_{100}, N_{200}), where also soil pH had the most acid values (pH 5.99; 6.33). Available zinc content decreased about 50 % at high doses of phosphorus and potassium fertilizer.m

Manganese availability increase as soil pH decrease. Manganese toxicity is common in acid soils pH < 5.5. On the other hand, manganese deficiency is most common in soils with pH above 6.5 (SCHULTZE, 2004). Available manganese content ranged between 134.8 ÷ 162,9 ($mg \cdot kg^{-1}$). The highest value was determined in $N_{200}P_0K_0$ variant, at pH 5.99 (the most acid value). Increasing P and K doses, we observed that available Mn content decrease, but not significant.

Copper availability is affected substantially by soil pH, decreasing 99% for each unit increase in pH. In soil, below pH 7.3, dominate Cu^{2+}, while, above pH 7.3, dominate $Cu(OH)^+$ (MORTVEDT, 2000). Available copper content ranged between 10 ÷ 12.5 ($mg \cdot kg^{-1}$). The highest values were observed at high nitrogen dose and low P and K doses. Increasing P and K doses, available cooper decrease slowly, to 10 mg·kg^{-1}.

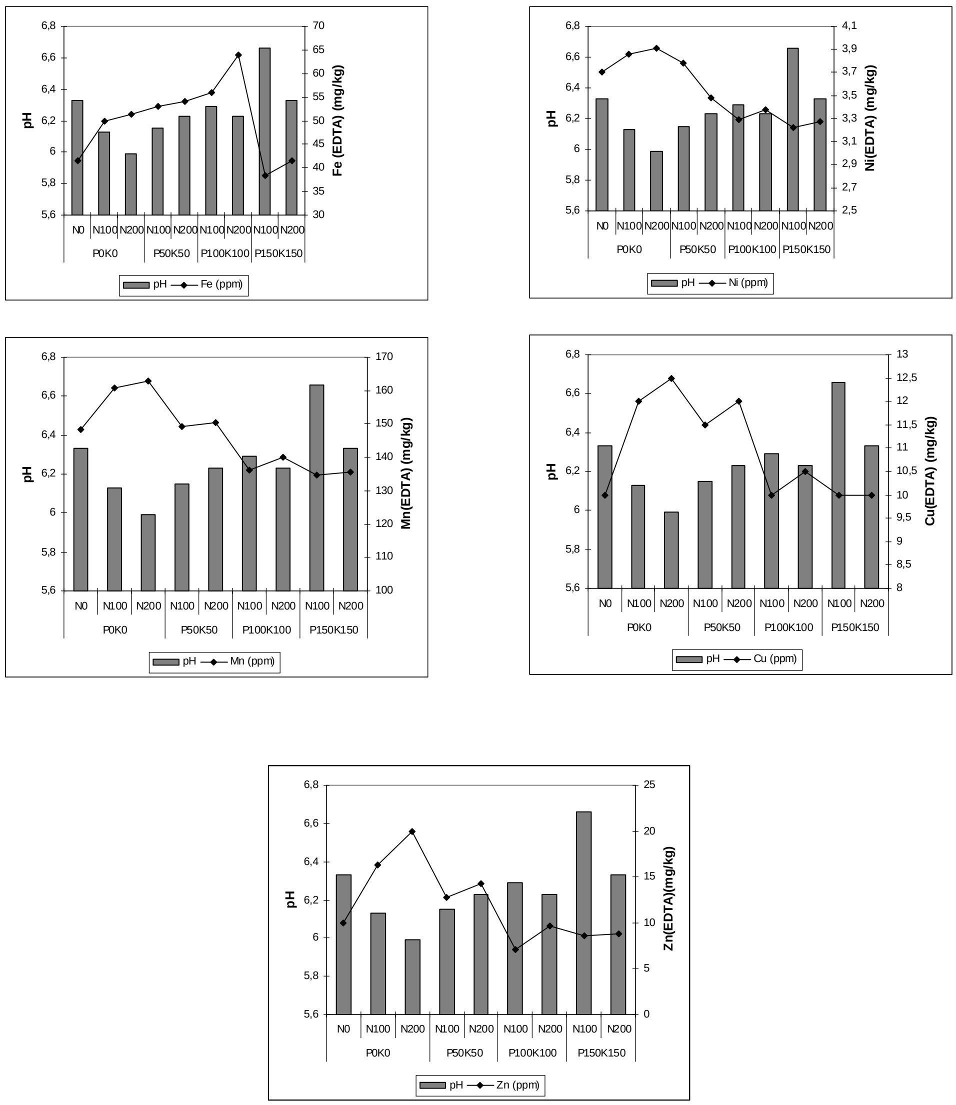

Figure 1: Influence of mineral fertilization on soil pH and availability metal content

Available nickel showed not significant modification with mineral fertilization, ranged between 3.2 ÷ 3.91 (mg·kg^{-1}). The highest values were determinate in case of high nitrogen doses, and low phosphorus and potassium doses ($N_{100}P_0K_0$, $N_{200}P_0K_0$). Increasing P and K fertilizing doses, we observe a slow diminishing of available Ni content.

CONCLUSIONS

From total content of metals in soil, only a small part is available. Metal availability strongly depends on pH, which is influenced by the level of mineral fertilization. High doses of nitrogen fertilizers (N_{100}, N_{200}) in absence of phosphorus and potassium fertilizers, determine soil acidification. In these conditions, we observe the highest values of available content of zinc (16,3 and 19.5 $mg \cdot kg^{-1}$), manganese (160.7 and 162.9 $mg \cdot kg^{-1}$), copper (12.5 and 12 $mg \cdot kg^{-1}$) and nickel (3.91 and 3.86 $mg \cdot kg^{-1}$). At the same nitrogen doses, but in the presence of phosphorus and potassium fertilizers, at different levels ($P_{50}K_{50}$, $P_{100}K_{100}$ and $P_{150}K_{150}$, we observed a decrease of available content of Zn, Mn, Cu and Ni because of pH increase (that limit metal availability) and by the other hand, because of metal-phosphate combination which are forming in P excess condition. The most affected by mineral fetilization seems to be the available zinc content which decrease with allmost 50% with increasing phosphorus and potassium doses. Available iron content increase with increasing the nitrogen, phosphorus and potassium. The highest values (56 and 64 $mg \cdot kg^{-1}$) were determinated in $N_{100}P_{100}K_{100}$ and $N_{200}P_{100}K_{100.}$ With increasing phosphorus and potassium doses ($P_{150}K_{150}$), the available iron content decrease mainly because iron fhosphates formation.

We considered that chemical fertilization must be applied in doses in accordance with plants demands and soil chemical features in order to avoid soil properties depletion, deficiency or excess, soil pollution and, not at least yield quality diminishing.

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