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THE SEWAGE SLUDGE INFLUENCE UPON COPPER CONTENT IN THE LUVOSOIL-PLANTS ECO-SYSTEM

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Abstract

Another heavy metal-copper (Cu), is part of the agricultural environment. The concentration below which it is in the ground depends on several factors. Of these organic matter (OM) expressed by quantity and evolution play a role in the cross-circuit composed of soil-plant system. In order to improve luvosoil OM of domestic sludge anaerobic digestion was used and dried. The contents of soil evolution was observed using doses of sludge as fallows: between 0 and 50 t.ha^{-1} with and without chemical fertilizers. Applying these organic- mineral fertilizers has contributed to increased plant biomass of: maize, wheat and soybeans. With increasing total biomass took place and a more pronounced absorption of Cu ions (Cu^{2+}). Correlations obtained between total biomass and leaf Cu contents show obvious increases, provided statistics on soybeans and wheat in year 4. Grain productions were negatively correlated with Cu, but the uncertain values significant. Such research with finding new methods for improvement of cross-cultural environment is needed for the majority highlight aspects of nutrition of plants in each hand.

INTRODUCTION

The existence of copper (Cu) in nature is strongly related to the contents of soil parent material originally evolved. Heavy metal accumulation in arable horizon is favored both by growing plants and the contribution of organic matter (OM) from different sources. Thus, if lithosphere contains about 100 mg Cu, soils contain between 2 and 100 mg [1, 5]. Recent estimates show content in the soil ranging between 1-37 mg Cu total forms and 3-14 mg Cu mobile ones [7]. However, the levels that are found with plant roots in the area is not the most important factor for absorption and thus to use it in normal physiological processes [15]. Copper is found in soil in the form of ion- Cu^{2+} (highest proportions) as well as neutral insoluble salts, other water soluble components as well as mineral-rich with [2]. The ions are absorbed on clay minerals and in a way related to organic matter. Absorption cross - Cu^{2+} in soil environment occurs depending on a number of factors. The most important are: pH, organic carbon (OC) content, presence of other metal ions, humidity etc. Positive influence on soil acidity Cu^{2+} absorption with the possibility that as the ions increases with pH values to be less active. Cu-MO complexes vary in stability over a variety of cases and are explained by the existence of different links to print the nature of trade between the mineral [17]. In this case, they will be detained for such a complex, sometimes not [13]. Instead the association with-clay has a degree of hydrolysis so that Cu^{2+} on clay is more easily absorbed by plants [6]. In comparison with other metal ions Cu^{2+} reduces Fe and Mn availability and in turn is inhibited by Zn and Mo [7]. Copper is absorbed by plants for normal functioning of normal physiological processes [4, 10]. Any plant that grows normally contains certain concentrations of Cu^{2+}. The control of crop plants show some states between deficiency and excess. Deficiency occurs in concentrations of 3-4 mg Cu in the leaves [1]. The normal values are below 10 mg. From this point of view of literature data shows a relative uncertainty. Toxicity occurs when the concentration of soil and plant exceeds certain limits. An estimate of toxicity shows that, over 20 mg of plant leaves, copper becomes dangerous [1, 12]. On acid soils, toxicity to the exchange takes place over 50 mg. Excessive concentrations of copper can be achieved by applying sewage sludge resulting from urban waste water treatment. Raw sludge obtained by processing and dewatering can be used as organic fertilizer only if the Cu content does not exceed legal standards [18]. Such sludge processed is used in this experiment due to the high content in macro- nutrients and a moderate copper level.

MATERIAL AND METHODS

In the period 2004-2007, a complex experiment was initiated. During this experiment, plants were cultivated by the structure: 1.- maize, 2.- winter wheat, 3.- soybeans and 4.- winter wheat. In normal cultivation technologies these plants were fertilized with different rates of organic- mineral. Thus, these rates were applied to sewage sludge: 0 $t.ha^{-1}$, 5 $t.ha^{-1}$, 10 $t.ha^{-1}$, 25 $t.ha^{-1}$ and 50 $t.ha^{-1}$.

The sewage sludge suffered an anaerobic digesting followed by dewatering within the Pitesti Wastewater Treatment Plant. Chemical fertilizers were differentiated on three levels: unfertilized, needs to 1/2 of normal and total rates (1/1). Plants have received such $N_{50}P_{50}$/maize, $N_{60}P_{40}$/wheat, $N_{30}P_{30}$/soybeans and $N_{40}P_{40}$/wheat for doses ½ and $N_{120}P_{80}$/maize, $N_{120}P_{80}$/wheat, $N_{60}P_{60}$/soybeans and $N_{80}P_{80}$/wheat for the 1/1 doses. Sludge rates were applied in the same quantities in the first two years- from maize and wheat in year two, following that soybeans and wheat in the past year to receive their residual effect.

The experiment with the lot divided had the A factor-sludge doses and the B factor-chemical fertilizers rates. Each variant had a surface of 100 m^2 each and was rehearsed (replicated) for three times. Leaves samples were taken during flowering period: in maize the leaves located at cob level, in winter wheat the last 3 leaves including the standard leaf and the soybeans the leaves in the central area of the plant but also with bean-pods in formation process. Soil samples were collected with the agrochemical sampling device of arable horizon 0-20 cm, between flowering to maturity period.

Chemical analysis were performed according to the latest European standards and methodologies: copper leaf and ground forms total - SR ISO 11047-99, mobile forms of ground - SR ISO 14870-99, both over sludge an-aerobically digested and over soil and plants. The data were statistically processed by analysis of the variant (Anova test) and with the help of correlations and regressions.

RESULTS AND DISCUSSION

Cu contents in the cultivation environment (soil). Ground measurements performed revealed heavy metal forms both by total and by mobile forms (Table 1). The data show that copper in soil culture was present in high levels. Thus, the total ranged between 14.1 and 27.6 mg of the limit and between 17.03 and 22.5 mg as annual averages. In comparison with literature data led to experiment with was of sufficient levels of good (great). Course to improve soil contributed to the heavy metal processed and dewatered sewage sludge. Mobile forms of Cu were between 3.0 and 7.4 mg of the limit and between 3.48 and 5.87 mg as the average. Both forms of Cu total and mobile demonstrates ensuring favorable environment for the absorption and translocation of this element, and particularly important in ensuring the growth and development of plants [17]. Sewage sludge increased soil content in copper with 1.11 mg in total forms and 0.37 mg in mobile forms. These concentrations demonstrated that the item was actually a chemical micro- nutrient valuable plant available.

Table 1

Copper concentrations from luvosoil cultivated with field crops

Crop plants	Cu, mg.kg^{-1} d.w., total forms		Cu, mg.kg^{-1} d.w., mobile forms	
	limits	media	limits	media
Maize	19.7 – 27.6	22.95	4.9 – 7.4	5.87
Winter wheat	18.7 – 24.7	20.78	3.0 – 4.0	3.48
Soybeans	15.2 – 18.8	17.03	3.3 – 5.2	4.07
Winter wheat	14.1 – 23.8	19.19	3.7 – 6.7	4.64

Influence of experimental factors on the content of Cu in leaves and grains. Given the favorable conditions in the cultivation soil, field plants absorbed Cu in the vegetative organs. Copper is considered an essential micro- nutrient. The average concentration of plants would be the situation in general between 5 and 20 mg [1]. Between 4 and 5 mg with the leaves is considered a danger zone that begins with deficiency [7]. Given the limits of this deficiency and heavy metal excess, plant analysis highlighted moderate concentrations of copper. In case of the biometric analysis of the three plants (Figure 1) found the existence of positive correlations with levels of copper. Thus, total biomass produced was directly correlated and increased concentrations of Cu accumulated in the leaves during flowering. The slope of the correlation is quite obvious 3 which shows the favorable effect of sewage sludge doses, chemical fertilizers doses and absorbed doses of copper. In statistical terms- the only two correlations of soybeans and of wheat since last year have provided the level of significance. These situations could emphasize the characteristics of the three plant nutrition in relation to Cu. Compared to maize and soybeans, wheat in the year-two ranked lowest on oscillation contents of copper depending on biomass, and in terms of absolute values the soybeans has absorbed more. Of the three, soybeans plants has a deep root system and developed what could explain the absorption Cu at the highest levels. In the final phase- at maturity there was noticed that the plants have deposited Cu in grains. Representing one of the constitutive plants' element, Cu was initially absorbed, transposed through xylem and phloem, and contributed to a better enzymes regime functioning, in the synthesis of chlorophyll and fruition, then Cu deposited into grains. Thus a Cu export phenomenon took place, from the cultivation environment into the grains.

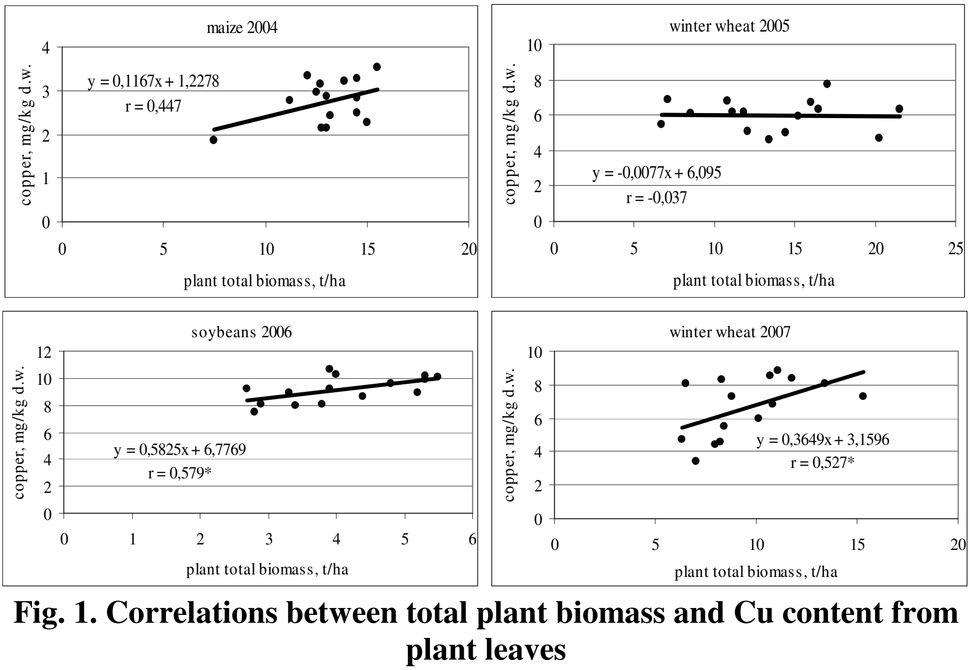

Fig. 1. Correlations between total plant biomass and Cu content from plant leaves

Regressions were thus set between the grains production formed and the Cu concentrations in grains, with slightly trends, with few data fluctuations (Figure 2). This demonstrates on the one side that at maturity plants no longer need Cu, and their value was relatively variable compared with the grains production. With higher values of copper from grain were determined in soybeans, the lowest in maize and winter wheat was intermediate.

<u>Expressing Cu^{2+} concentrations in the cultivation plants.</u> Plants need the field of copper ions. To avoid deficiencies and excesses well as periodically to carry out state supply plant with. Usually companies producing micro- nutrients resorting to estimates, which are a milestone in ensuring the complex feeding of the plants. To some estimates, experimental results have shown different situations (Table 2). By Yara [19], with recent data, young plants need in stages of 4.10 mg Cu. In comparison with these average date obtained showed that for maize were needed in leaves 3 mg Cu, wheat 7 mg and 10 mg soybeans. In the final stage, the mature plants were content with the level of 2 mg Cu in maize grains, 6 mg Cu in wheat grains and 17 mg Cu in soybeans grains. Hence it is clear the different nature and specific absorption and translocation of copper by field plants. An important step is to ensure sources with micro- nutrients, and from these domestic sludge is perfectly adaptable because of its high mineralization capacity.

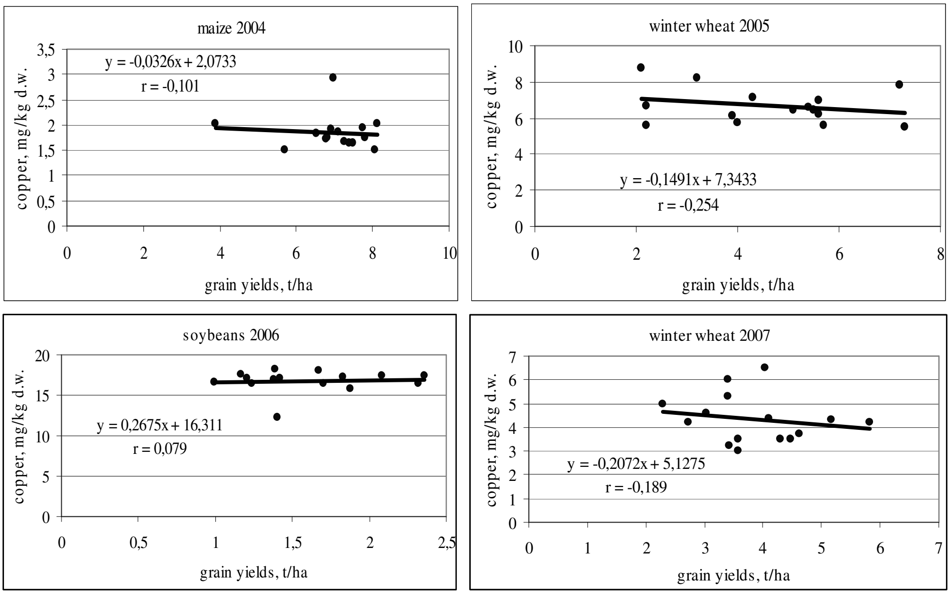

Fig. 2. Correlations between grain yields and Cu content from plant grains

Table 2

Expression of the Cu^{2+} concentration ($mg.kg^{-1}$ d.w.) from field crops

Crop	Necessary amounts for growing period*)	Plant determinations	
		Flowering stage	Maturity stage
Maize	10	3	2
Wheat	5	7	6
Soybeans	4	10	17

*) YARA

CONCLUSIONS

1. Sewage sludge improved the feeding regime of the plant, including copper (Cu), an indispensable micro-nutrient for the plants. Soil Cu total forms increased with 2 $mg.kg^{-1}$ d.w. with the used doses of sludge. Mobile forms increased with 1 $mg.kg^{-1}$ d.w. due to the sludge contribution.
2. Biomass production increased in an evident manner as a result of optimal feeding conditions creation. Correlations between the biomass and the Cu content in leaves demonstrated the Cu absorption and movement in direct relation to its increase.
3. Copper was deposited in the useful production-grains, which stand for an export of this essential micro-nutrient. Regressions between grains production and Cu concentrations showed a relative standstill.
4. Plants needs in terms of Cu ions presented specificity issues, in close relation with both environment factors and the feeding sources ensured. Sewage sludge ensure non- hazardous Cu quantities, having due to the mineralization degree the quality of bio-nutrient.

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