

## RESEARCH ABOUT MANGANESE REGIME FROM AGRICULTURAL ECO-SYSTEMS IMPROVED BY THE SEWAGE SLUDGE

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### Abstract

*Mn is another element in the category of heavy metals, which in small quantities is useful in feeding the plant, while the excess could induce specific phytotoxic phenomena. For the purpose of observing trends of Mn content of plants were used progressive sludge doses: between 0 and 50 t.ha<sup>-1</sup>, with doses of chemical fertilizer: 0, ½ and 1/1 of crops specific needs. In general, mobile Mn ranged between 400 and 650 mg, which are relatively high concentrations. Under these conditions the plants have absorbed field Mn<sup>2+</sup> ions in specific quantities. The correlations obtained between the contents of Mn and complex doses shows obvious increase in leaves of maize (r=0.832\*\*\*) and soybean (r=0,530\*), inconclusive in wheat (both years), and decreased concentrations of Mn in the three species grains. Such researches might reveal some aspects in relation to nutrition with micronutrients such as Mn, of each plant part.*

**Key words:** luviscsoil, maize, Mn, processed sludge, soybean, wheat.

### INTRODUCTION

In its current state, the luviscsoil contains Mn in appreciable quantities, having its origin in the decomposition of ferromagnetic rocks. After iron (Fe) and aluminium (Al), manganese (Mn) represents the most abundant chemical constituent in rocks making up the earth shell [7]. Soil contains transformed Mn under different forms associated with the mineral and organic part.

The most common are Mn oxides and hydroxides. They can originate from the parental material or alteration process. Both Mn crystalline and amorphous state exist under more forms, including ferromanganese balls or concretions. Their forming has at their base the alternation of oxidation and reduction processes (Photo 1). Dominant forms of Mn in the ferromagnetic concretions composition (balls) are represented by Mn<sub>2</sub>O<sub>3</sub>.nH<sub>2</sub>O [3].

In order to become accessible for plants, Mn oxides and hybrids need to be reduced to

Mn<sup>2+</sup> ions. Between Mn<sup>2+</sup> from soil solution, Mn<sup>2+</sup> changeable and superior oxides of Mn there is a dynamic balance controlled by the complexity of the reduction conditions (redox potential).



Photo 1. The Mn concretions from luviscsoil (original)

Accessibility of Mn<sup>2+</sup> depends of several factors, among which the most important are: pH, microbiological activity, organic matter (OM) and soil's humidity regime. The last researches proved that the availability of

Mn<sup>2+</sup> occurs in soils with pH contained between 5 and 6. Mn<sup>2+</sup> is thus present mainly in acid soils, while on neutral soils manganese is under a trivalent form (Mn<sup>3+</sup>) as Mn<sub>2</sub>O<sub>3</sub>, and in alkaline ones (pH over 8) under tetravalent form (Mn<sup>4+</sup>) in an inert oxide, MnO<sub>2</sub> [11].

Luvicsoil having as characteristic the acid environment [10] favors the reduction processes following which manganese is in bivalent form - Mn<sup>2+</sup>, available for plants absorption [2]. The specific microbial activity here is reduced, leading to a true conservation of accessible Mn<sup>2+</sup> forms. OM influences the mobility of Mn<sup>2+</sup> both by lower affinity compared with other heavy metals, being thus permanently available and by the specific decomposition degree. Due to unfavorable drainage the reduced forms of Mn are predominant by stimulation of bacteria which decompose OM using Mn oxides as O<sub>2</sub> source.

It is such noted that luvicsoil specific to Pitești Research Center contains Mn accessible to plants in relatively higher concentrations. A safe source of OM for local agriculture is represented by the digested sludge [5] from Pitesti Wastewater Treatment Plant. Being qualitatively comparable with manure [1, 9] sludge such processed represents a new source both for macro-nutrients for agricultural plants: nitrogen, phosphorus, potassium, calcium etc., but also for micro-nutrients among which manganese is in concentrations close to the ones of the soil.

## MATERIAL AND METHOD

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 doses of organic-mineral. Thus, these doses were applied to sewage sludge: 0 t.ha<sup>-1</sup>, 5 t.ha<sup>-1</sup>, 10 t.ha<sup>-1</sup>, 25 t.ha<sup>-1</sup> and 50 t.ha<sup>-1</sup>. The sewage sludge suffered an anaerobic digesting followed by dewatering within Pitesti Wastewater Treatment Plant (Photo 2).

Chemical fertilizers were differentiated on three levels: unfertilized, needs to ½ of normal and total doses (1/1). Plants have received such N<sub>50</sub>P<sub>50</sub>/maize, N<sub>60</sub>P<sub>40</sub>/wheat, N<sub>30</sub>P<sub>30</sub>/soybeans and N<sub>40</sub>P<sub>40</sub>/wheat for doses ½ and N<sub>120</sub>P<sub>80</sub>/maize, N<sub>120</sub>P<sub>80</sub>/wheat, N<sub>60</sub>P<sub>60</sub>/soybeans and N<sub>80</sub>P<sub>80</sub>/wheat for the 1/1 doses.



Photo 2. The processed sewage sludge used

Sludge doses 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 doses. Each variant had a surface of 100 m<sup>2</sup> each and was rehearsed (replicated) for three times.

Leaves samples were taken during flowering period: at maize the leaves located at cob level (Photo 3), at winter wheat the last 3 leaves including the standard leaf (Photo 4) and the soybeans the leaves in the central area of the plant but also with bean- pods in formation process.



Photo 3. The maize leaves samples taking moment



Photo 4. The wheat leaves samples taking moment

Soil samples were collected with the agrochemical sampling device of arable horizon 0-20 cm, between flowering to maturity period. Chemical analysis was performed according to the latest European standards and methodologies: Mn/soil, leaves and grains- SR ISO 11047-99, Mn- 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 and with the help of correlations and regressions.

## RESULTS AND DISCUSSIONS

### Mn contents of cross-cultural environment.

Following the determinations made soil Mn content of heavy metal demonstrate both the overall shapes and forms as total and mobile manganese in the soil. Total manganese in the soil ranged from average to good values considered (Table 1). Thus, in the four years ranged from 661-795 mg.kg<sup>-1</sup> d.w. Mn the minimum and 861-1050 mg.kg<sup>-1</sup> d.w. the maximum values.

Table 1. Mn contents from soil (mg.kg<sup>-1</sup> d.w.) total forms

Heavy metal	Maize	Wheat, 2	Soybean	Wheat, 4	Toxic limit
Mn, limits	769 – 899	661 – 861	758 – 981	795 – 1050	> 2000
Mn, average	829	766	849	910	

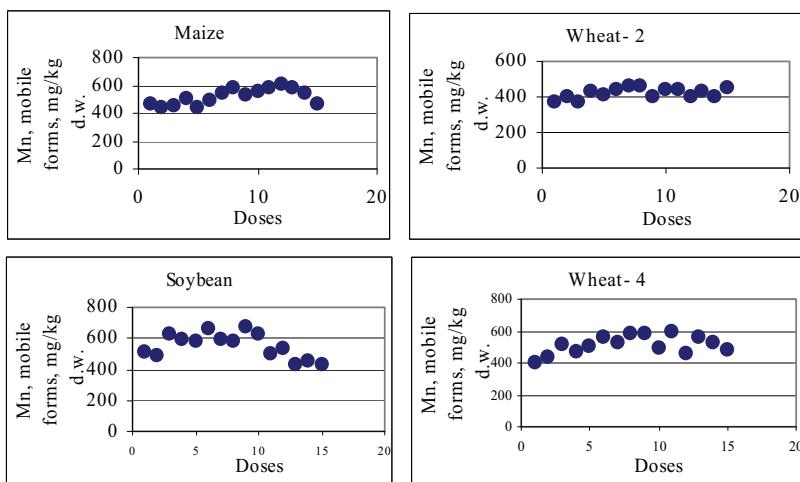


Fig. 1. The evolution of mobile Mn concentrations depending on the doses of sludge & chemical fertilizers applied

Due to domestic sludge introduced into the soil, mobile Mn known quite positive and relative developments (Fig. 1). Depending on the dose used, mobile Mn ranged from 400 to 650 mg.kg<sup>-1</sup> d.w. in four years. Since the limits of Mn is between the normal, this state contributes to ensuring good conditions for plant nutrition [12, 13]

Experiments on the influence of Mn content in leaves and grains. Given the soil conditions of culture, in which both the total and mobile forms of Mn were at high enough levels, it was expected than Mn<sup>2+</sup> uptake by plants have the same extent.

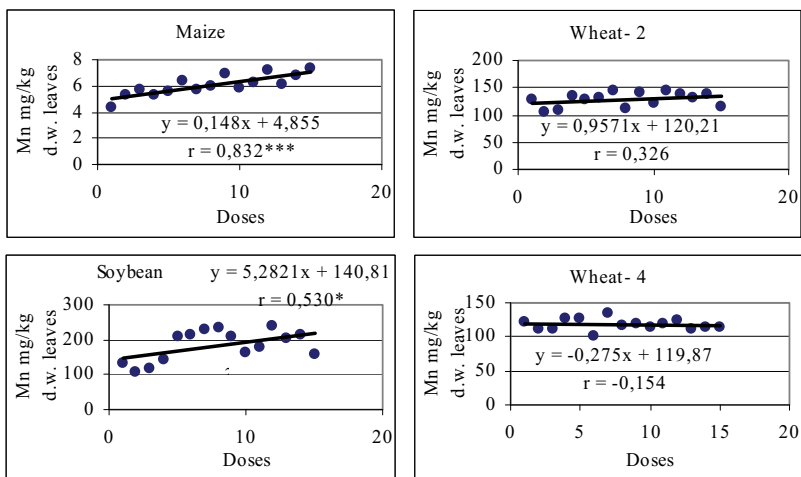


Fig. 2. Mn concentrations evolution from leaves of plant, flowering period

High levels of  $Mn^{2+}$  in the soil can result in phytotoxicity (Photo 5) phenomena [4, 8].



Photo 5. The Mn excess on maize leaves

In the extreme, of great importance is the analysis of plant, in several moments of plant life. Both Mn and other chemical elements, minerals etc, are selectively absorbed by each plant species [1]. Mn content of plant leaves showed different aspects (Fig. 2). Maize contained in its leaves between 4-7 mg.kg<sup>-1</sup> d.w. Mn. Experimental factors very obviously increased leaf Mn content ( $r = 0,832^{***}$ ). In the same way ( $r = 0,530^*$ ), Mn in leaves of soybean growth experienced obvious limit values between 120 and 210 mg (Photo 6). In wheat leaves Mn concentrations have been less upward, even capped. Absolute levels ranged between 100 and 150 mg in the two years.



Photo 6. The wheat leaves samples taking moment

The correlations obtained between doses of fertilizers complex with Mn concentrations of grains shows characteristic differences, different from those in leaves, due to negative trends (Fig. 3). Thus, decreasing state were obtained from maize in the first year with the index of correlation  $I = 0,589$ , the soybean third year,  $I = 0,100$  and wheat last year,  $I = 0,531$ . Wheat in the second year has seen increases in grain Mn,  $I = 0,513$ . Negative trends of Mn correlations show that the mature plants had no need of this micronutrient.

Agrochemical indices that limit transfer of Mn in the agricultural medium. Recently succeeded in limiting the development of indices (344/708/2004 Ord.) concentrations of

Mn [6] of agricultural land, when applying sludge waste (Table 2).

The first index, the maximum tolerable intake of Mn from domestic sewage:  $MTI_{Mn}$  concentrations will be below  $1084 \text{ mg.kg}^{-1}$

d.w. Mn. The second indicator, annual allowable sludge waste time: AN was at  $4 \text{ t.ha}^{-1}$ . For a 4-5 year cycle of crop rotation, can be applied between  $15\text{-}20 \text{ t.ha}^{-1}$  sludge waste.

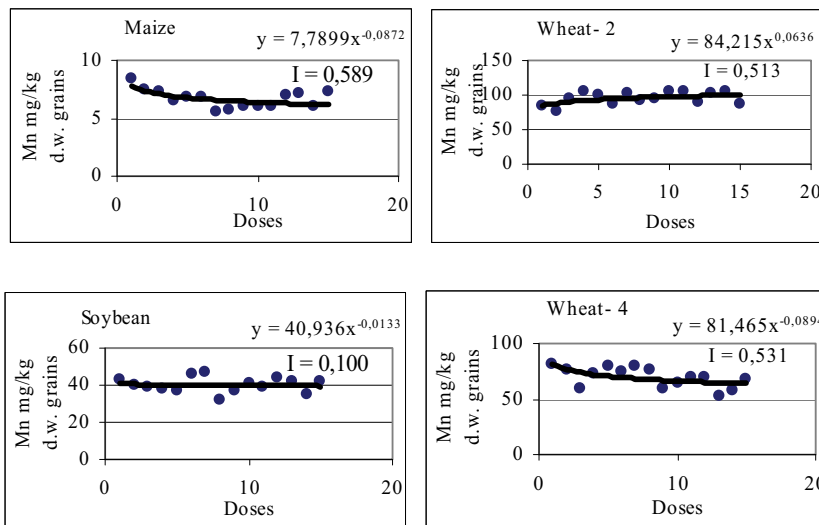


Fig. 3. Mn concentrations evolution from grains, maturity period

Table 2. Indices of mobile Mn-  $\text{mg.kg}^{-1}$  d.w. (after Borlan, 1994)

Indices		Calculation
Mn	Maxim tolerable intake	$MTI_{Mn} \leq 3400.CEC/35 \leq 1084$
	Annual allowable norm	$AN_{Mn} = 3400.CEC/35.Mn = 4 \text{ t.ha}^{-1}.y^{-1}$

\*CEC, cationic exchange capacity ( $11,16 \text{ me}/100 \text{ s.u. soil}$ )

## CONCLUSIONS

By using processed sludge (anaerobic digestion and dehydrated) has been a relative improvement of the soil eco-environment. Average levels of the four experimental years showed a significant increase in mobile forms of Mn, between  $400$  and  $650 \text{ mg.kg}^{-1}$  d.w., with a tendency to decrease. High concentrations of mobile Mn here is not any danger to plants, because its absorption takes place each active and specific crops.

Sludge and chemical fertilizers have significantly changed the Mn content of leaves. Soybean contained the most Mn:  $140\text{-}210 \text{ mg}$ , with  $r = 0.530^*$ . Wheat Mn content

of  $120 \text{ mg}$ , with the increase (year 2) and fall (year 4), and maize increased between  $5$  and  $7 \text{ mg}$ , with  $r = 0.832^{***}$ .

Correlations obtained with the production of useful product (grain) show that Mn in growing plants used after they have deposited in the grain, in an inverse relationship. Mn mature stage was not necessary and that the contents:  $6\text{-}7 \text{ mg}$  in maize,  $80\text{-}100 \text{ mg}$  in wheat and  $40 \text{ mg}$  in soybean, were exported by grains.

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