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RESEARCH REGARDING THE INFLUENCE OF SEWAGE SLUDGE IN ORGANIC AGRICULTURE

G. MUJEA*, N. IONESCU, MARILENA DIACONU*, ANA IORDANESCU***

*Wastewater Treatment Plant Pitesti Company
**Agricultural Research and Development Station of Pitesti

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Abstract

In case of plants cultivation in organic agriculture, the completion of organic-mineral support is decisive in providing the feed, both in quantitative and qualitative terms. Research performed both to us and in other parts have demonstrated that an extremely valuable support material for agriculture is represented by the sewage sludge. In case of luvosoil there were used progressive doses of sludge, respectively: 0, 5, 10, 25 and 50 t.h^{-1}, with the aim of observing the trends in terms of improving the organic matter reserves. Generally the organic carbon (OC) content increased from approximately 1.5% to over 2%. Due to this fact there was also noticed an increase of total vegetal biomass and an increase in terms of grains, mainly for cultivated field crops, respectively maize, wheat and soybeans. In the same time, the heavy metals content has situated at the lowest levels, not dangerous, some representing in fact microelements: Zn, Cu, Mn.

INTRODUCTION

One of the valuable and available resources for completing the field plants' needs in terms of nutritive elements is represented by sewage sludge. Its obtaining follows a common processing method in the Wastewater Treatment Plant Pitesti and contains considerable quantities of: organic carbon (OC) 25-35 %, macro- and micro-elements, having also a neutral reaction-pH= 6.95-7.20. The specific contents relatively high in fertilizing elements [2, 6] recommends the usage of sewage sludge for field crops cultivation. Recent researches compare the sewage sludge with manure, while a major advantage related to the sludge is represented by the fact that the mineralization process takes place in a very short timeframe, plants taking advantage of those respective nutrients in a short time: total nitrogen, phosphorus, potassium, calcium, magnesium. Yet sewage sludge contains also some heavy metals, some representing microelements with low concentrations [3, 4]. As known, sewage sludge usage for the field crops cultivation requires the specific levels of these heavy metals to be under the admissible European an national levels (Order 708/344, 2004). Until present, two main directions have been considered when using sewage sludge: the organic matter contribution to ensuring the plants needed food, together with observing the heavy metals content, both directions being perceived as guarantees in obtaining some clean plants, grown-up in a normal way. In the present paper, there are presented the results obtained using sewage sludge, in different doses, for the purpose of improving luvosoil's nutrition regime, based on the principles of organic agriculture. As known, in case there is achieved the improvement of the luvosoil's content in terms of organic matter, there is also ensured in broad terms the supply of the plants with fertilizing elements, during the entire vegetation process. In the same time, there are to be observed the levels of the heavy metals in the entire specific eco-system: soil-green organs (leaves on flowering) - mature organs (grains).

MATERIAL AND METHODS

The study regarding the sewage sludge effects upon the agricultural environment contained some complex researches. A cropping system with a duration of 4 years was initiated, for the period 2004-2007 with the following configuration: year 1 for maize, year 2 for winter wheat, year 3 for soybeans and year 4 for winter wheat. Different doses of sludge were used: 0 $t.ha^{-1}$, 5 $t.ha^{-1}$, 10 $t.ha^{-1}$, 25 $t.ha^{-1}$, 50 $t.ha^{-1}$, with and without chemical fertilizers. The present data describe separately only the influence of sewage sludge upon the agricultural environment. The sludge doses were applied in the same quantity in the first 2 years-for maize and wheat in year 2, with soybeans and wheat in the last year allowed to benefit of the remaining effect of these initial doses. Experimental variants (plots) had a surface of 100 sq.m each, in three replications. The cultivation technology of these 3 field plants was the one recommended by the agricultural research station. Chemical analyses performed were according to the last European norms and methodologies (OC- SR ISO 10694-98, heavy metals in leaves and soil, total forms- SR ISO 11047-99, and mobile forms in the soil- SR ISO 14870-99). Soil samples were collected with the agrochemical check-rod from the cultivation horizon 0-20 cm, when plants reached their maturity phase. The organic carbon content in the soil with sewage sludge was determined in all of those 5 average samples. In the same maturity phase those 3 plants were harvested, while their total vegetal mass (dry) was measured. Between the soil's content in OC and the vegetal mass there were determined specific correlations in all those 4 cultivation years. Regarding the heavy metals, several chemical analyses were performed, as follows: i) from the cultivation soil, for total contents and mobile ones; ii) from plants' leaves during the flowering period, specially: leaves corresponding to maize cobs, the last leaves under the wheat ear and respectively from the central part of the soybeans stalk; iii) from the grains in the maturity phase. Determination performed were intended to analyze the following heavy metals: lead (Pb), cadmium (Cd), zinc (Zn), copper (Cu), nickel (Ni), and manganese (Mn).

RESULTS AND DISCUSSION

The contribution of sewage sludge used in the cultivation soil was analyzed in two ways. Chemical analyses were performed for determining the organic matter accumulations and heavy metals contents.

The cultivation soil contains organic matter (OM) coming either from the accumulation of vegetal and animal matter, or in the form of fertilizers, both sources suffering of decompositions or colloidal dispersion [1]. The basic component of the organic matter is represented by humus. In a continous dynamic phase, more or less stable, humus is the result of several biological, chemical and bio-chemical processes [9]. Humus contains a very valuable chemical element-carbon, which stands for a very important ratio- of over 55%.

Sewage sludge contains in a certain ratio this OC, more exactly a ratio of over 30%, with the macro- elements also presenting high levels, as follows: total nitrogen 2.25%, phosphorus 1.25%, potassium 0.35%, calcium 1.90% [5]. The way luvosoil was improved in terms of organic carbon as an effect of using sewage sludge (figure 1).

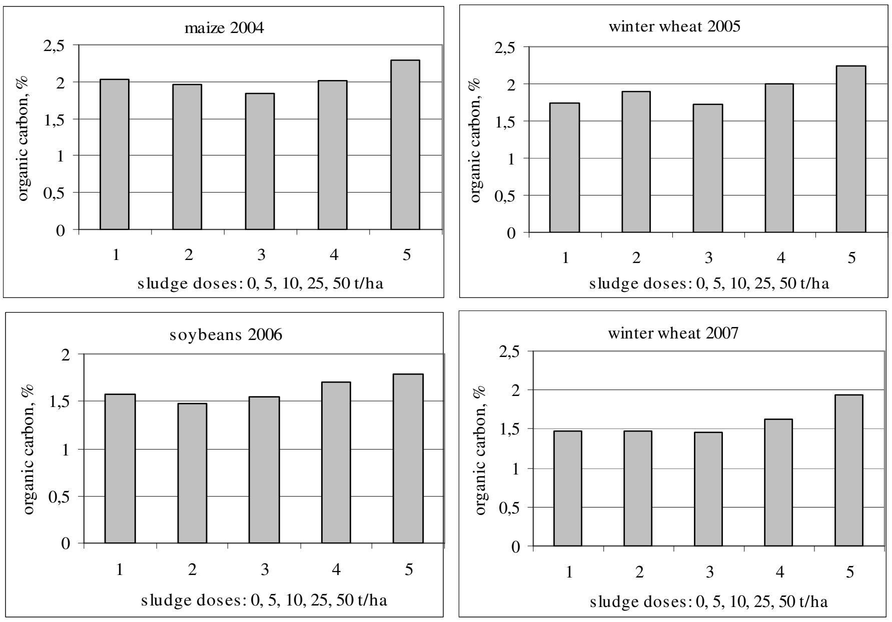

Fig. 1. The influence of sludge doses over soil's organic carbon (OC) contents

Of the 4 situations, the OC contents in the soil were grouped in 2 categories. On one side, both maize in the 1st year and wheat in the following year have a OC content at slightly higher values. For maize, compared to the check plot without sewage sludge and in the first three doses, the OC content was situated around a ratio of 2%, while for the lot with 50 $t.ha^{-1}$ sewage sludge the OC content ratio increased to 2.30%. For wheat, sludge influenced the soil's content in OC starting from a ratio of 1.74% in the check plot without sludge and increased in the case of the lots with the first two sludge doses. At 25 t.ha^{-1} of sewage sludge the OC was found to be around 2%, while for 50 t.ha^{-1} the level was of 2.25%. In case of soybeans and wheat in the last cultivation year there was noticed the remaining effect of sludge, so the results were somehow lower. For soybeans the OC level was between 1.50% in the case of small doses and 1.79% in maximal dose. In case of wheat the OC content was of 1.50% in 4 variants and slightly increased- 1.93% in the case of largest dose of sludge. Being separated, the two situations for sludge effect: direct contribution and remaining effect, there can be capitalized the feature of fast mineralization the sewage sludge possesses.

Based on the sludge doses used, the total biomass of all those 3 crops has increased (figure 2). Biomass growth rates were the following: 491 kg total d.w. (dry weight) maize/10 t.ha^{-1} sludge, 909 kg total d.w. wheat/10 t.ha^{-1} sludge, 277 kg total d.w. soybeans/10 t.ha^{-1} sludge and 334 kg total d.w. wheat/10 t.ha^{-1} sludge. Since data obtained are consistent they can provide a great level of reliability in valorization of this valuable material- the sewage sludge.

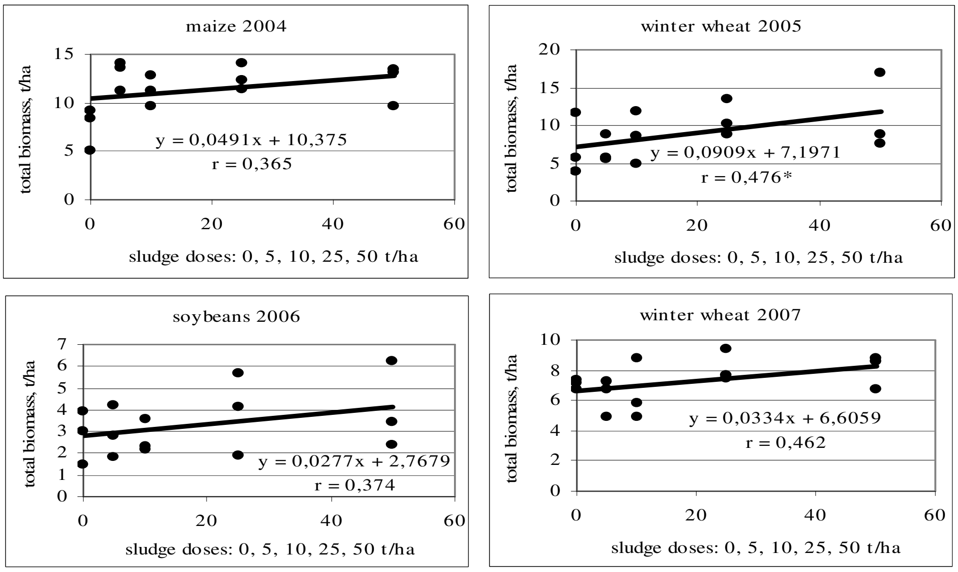

Fig. 2. Correlations between sludge doses and total field crops biomass

Heavy metals are component part of nature [7], including the agricultural environment. On one side the cultivation soil has specific concentrations of chemical elements, together with organic ones, while on the other side the sludge has its own contents. By mixing up the two systems- soil and sludge, accumulations of heavy metals can occur. The important issue is that both original concentrations and the additional ones to be contained within allowable limits, that are not hazardous (table 1). The average values obtained during the entire experiment show low concentrations, under the set limits. Total manganese forms in the soil, before and after using sludge, are slightly higher due to a luvosoil specific phenomenon [8]. Regarding the heavy metals contents in the plants (table 2), there were noticed very low levels of heavy metals, with slight fluctuations in leaves and grains. Lead was found only in the winter wheat; cadmium was discovered more in the maize grains and less in the wheat grains and soybeans; zinc recorded accumulations more in the maize and wheat grains and less in case of soybeans; copper was found more in soybeans, with the same situation in case of nickel; manganese was present in higher concentrations in the leaves of the 3 plants.

Table 1

The means values of heavy metals content in the luvosoil, without and with sewage sludge quantities

Heavy metals	Total forms		Mobile forms	
	without sludge ($mg.kg^{-1}$ dw soil)	with sludge ($mg.kg^{-1}$ dw soil)	without sludge ($mg.kg^{-1}$ dw soil)	with sludge ($mg.kg^{-1}$ dw soil)
Lead, Pb	17	20 - (50)*	6	7
Cadmium, Cd	0.130	0.210 - (3)	0.100	0.115
Zinc, Zn	112	83 - (300)	2.5	7
Copper, Cu	19	20 - (100)	4.2	5
Nickel, Ni	23	22 - (50)	4.7	5
Manganese, Mn	820	840 - (500)	440	500

*344/708/2004

Table 2

The leafs and grains heavy metals content after sludge doses application

Heavy metals	maize		wheat		soybeans		wheat	
	leaves	grains	leaves	grains	leaves	grains	leaves	grains
Lead, Pb	and*	and	2.1**	2.5	and	and	6.0	and
Cadmium, Cd	0.098	0.155	0.192	0.167	0,203	0.109	0.218	0.209
Zinc, Zn	9.4	23.9	31.9	71.5	71.7	49.0	18,7	36.6
Copper, Cu,	2.8	1.9	6.0	6.7	9.2	16.7	6.7	4.3
Nickel, Ni	1.5	0.8	2.3	4.2	8.5	37.3	3.8	3.5
Manganese, Mn	6.0	6.7	127.9	95.2	183.1	40.1	117.7	69.5

*and-andetectable, **$mg.kg^{-1}$ dw

CONCLUSIONS

1. Sewage sludge with important concentrations of organic carbon (OC), in macro- and micro- nutrients and with the heavy metals limits under the hazardous ones, stands for a very good organic fertilizer. With a maximal limit of 50 $t.ha^{-1}$ the sewage sludge can be used as a very good fertilizer for organic agriculture.
2. By using different doses of sludge there was obtained an improvement of the soil's content in organic carbon from 1.84% to 2.30% for maize and between 1.72% to 2.25% to wheat- as a direct effect of using sludge, and between 1.47% and 1.79% for soybeans and between 1.45% and 1.93% for wheat in the last year.
3. Luvosoil benefited of an improvement of its content in terms of organic carbon, creating the required conditions for obtaining higher vegetal productions. The cause is represented by the creation of some superior conditions for plants' growth and development.
4. Heavy metals, both total forms and mobile ones, had lower levels. Leaves and grains were prevalent regarding the absorbtion and translocation of heavy metals from the soil fertilized with sewage sludge.

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