Soil Amendment and Plant Fertilization by Residual Calcium and Magnesium

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The industrial process of magnesium carbonate and oxide manufacturing from dolomites by carbon dioxide leaching generates calcium carbonate as waste. Besides calcium carbonate, this precipitate contains magnesium carbonate, which can be useful in agriculture as amendment and fertilizer for low fertile acid soils. The paper shows the effects of soil treatment with different doses of industrial waste concerning the soil reaction and calcium - magnesium content, simultaneously with the growth process of green oat plants and their calcium - magnesium uptake. The obtained results indicate that soil reaction turns from acid to neutral, while the established increase for calcium content of soil have reached 51% and respectively 260% for magnesium content, both generated by the highest dose of experimented waste. For green oat plants, the results showed an increase of 117% for calcium uptake and 72% for magnesium uptake. The influence determined on the growth reveals a beneficial effect on germination and number of risen plants, a taller size of plants as well as a decrease of dry matter content at harvest time.

Key words: waste doses, soil reaction, calcium - magnesium content, plant growth

Huge amounts of waste proceeded by human activities like domestic daily activities, industry, agriculture or transport are increasingly becoming a global problem for the environment protection because of their composition and storage manner. Extensive ground areas covered with waste become useless polluting soil, surface and depth waters, crops and fodders. In order to avoid this situation, waste containing useful elements for soil amendment and fertilization can be recovered in agriculture [1-2]. Such an example is represented by the producing process of magnesium carbonate and oxide from dolomites by carbon dioxide leaching. Thus by carbonation of calcined dolomites slurries, the main product is magnesium bicarbonate, calcium carbonate results as waste [3-4]. The precipitate of calcium carbonate will include the impurities of the initial dolomite, as well as an important amount of magnesium carbonate [5-6]. Calcium and magnesium are two important mineral elements for soil and plant nutrition. Most of the soils do not fulfil the demands of plant nutrition during the vegetation period. Acid soils or those that easily become acid are considered low fertile soils. Frequently nutrients are leached out or become unavailable for plants. In order to enhance the fertility of soil, this waste can be used for soil treatment because of its composition. The presence of calcium and magnesium ions confers upon the waste an amendment and fertilizer role for acid soils with low content of calcium and magnesium. Magnesium has a catalytic role in plant nutrition taking part in the photosynthesis process and facilitating the circulation of some major nutritional elements. Calcium is used by plants in their physiological processes; it promotes the development of the root system and cell division, contributes to the consolidation of the stem which becomes fall resistant [7-8].

The main objectives of this study are to present the effects of soil treatment by different waste doses concerning both soil reaction and calcium - magnesium content of luvosoil, as well as the growth process and calcium - magnesium uptake of green oat (*Avena sativa L.*) plants.

Experimental part

The soil in the experimental pots is luvosoil, a rather low fertility soil, characterized by some data mentioned in table 1.

Luvosoil was collected, air-dried, crushed, mixted thoroughly with the waste dose and put into pots, each containing 1 kg soil. The waste used as powder for soil treatment had an average composition including 29.5% calcium and 6.5% magnesium. Like in the initial dolomites, the same inconstancy of the waste composition is noticed. The calcium content of carbonate content lies between 70.6-75.5% $CaCO_3$, the magnesium carbonate content expressed as MgO is 8.8-14.0%, insoluble impurities in hydrochloric acid are 0.6-1.35% to which 0.83-1.05% iron and aluminium oxides are added.

The experimental alternatives pursued by the research consist of four different waste doses (V_1, V_2, V_3, V_4) used as soil treatment (table 2) and one control alternative (V_0) represented by untreated soil. All the experimental alternatives took place in three replicates.

All the pots were sown with fifteen oat grains, watered every second day by 50 mL water. The pots were placed near the laboratory window. The pursued vegetation period was that of green plant, during 7 weeks, while the growth and development of the oat plants were studied. Some morphological and chemical parameters of the green oat plants along the vegetation period was established (number of risen plants, plant size, fresh and dry weight, dry matter at 105°C). At harvest time, the calcium and magnesium uptake in green oat plants was determined by use of atomic absorption spectrophotometry (AAS). Soil samples were collected at harvest time and were established their pH values, as well as the content of

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Table 1
SOIL CHARACTERISTICS

No.	Characteristics	Unit	Value
1.	Particle size distribution:		
	- Sand (2.0 - 0.2 mm), %	%	3.5
	- Fine sand (0.2 - 0.02 mm), %	%	49.6
	- Silt (0.02 - 0.002 mm)	%	33.1
	- Clay (< 0.002 mm)	%	13.8
2.	pH in water		5.8
3.	Macroelements content:		
	Ca^{2+}	me/100	70
	Mg^{2+}	me/100	48

Table 2
EXPERIMENTAL ALTERNATIVES WITH MINERAL ADDINGS IN SOIL

Experimental alternative	Waste dose, mg/kg soil		
	Amount	Calcium content	Magnesium content
V_1	180	53	12
V_2	360	106	23
V_3	720	212	47
V_4	1440	424	94

Table 3
EFFECT OF WASTE DOSES ON THE SOIL

Experimental alternative	Soil reaction		Calcium content		Magnesium content	
	pH	increase	mg/kg	%	mg/kg	%
V_0	5.80	-	87	100	10	100
V_1	6.40	0.60	90	103	21	210
V_2	6.45	0.65	100	115	26	260
V_3	6.66	0.86	118	136	34	340
V_4	6.93	1.13	218	151	36	360

calcium and magnesium. In order to determine the soil reaction, a watery soil solution (1:5) was used; the *p*H values were read by a pH-meter. Calcium and magnesium of soil were analysed by complexometric way with EDTA (complexon III.). All the obtained results, representing average values of three replicates, were compared with the control alternative.

Results and discussion

Influence of waste doses on soil

The treatment of luvosoil with four different doses of industrial waste showed important changes regarding soil fertility. Due to its composition, consisting mainly of calcium and magnesium carbonates, this waste had an important effect on soil reaction, improving the content of calcium and magnesium. The established values are distinct for each experimental alternative being shown in table 3.

The presence of this waste in soil had a neutralizing effect on the reaction of soil. Luvosoil, which had an acid *p*H, became neutral once with the increase of the waste dose. For the highest dose of tested waste (V_4), the pH value of soil have increased by 1.13 *p*H units and became neutral (6.93). The calcium content of luvosoil improved once with the increase of the administered waste dose; this increase

Table 4
INFLUENCE OF WASTE DOSES ON SOME VEGETATION CHARACTERISTICS OF THE OAT PLANT

Vegetation characteristics	Experimental alternative				
	V_0	V_1	V_2	V_3	V_4
Risen plants (number)	11.0	13.0	13.0	13.0	14.0
%	73.0	87.0	87.0	87.0	93.0
Size of green plants (cm)	27.3	29.0	28.3	31.3	31.3
%	100.0	106.0	104.0	115.0	115.0
Fresh weight (mg/piece)	268.0	233.7	195.2	221.3	213.3
%	100.0	87.2	72.8	82.6	79.6
Dry weight (mg/piece)	95.0	74.6	56.6	54.6	47.2
%	100.0	78.5	59.5	57.6	49.9
Dry matter (%)	35.7	32.0	29.3	23.2	22.6

Table 5
IMPACT OF THE WASTE DOSES ON SOME MACROELEMENTS CONTENT IN GREEN OAT PLANTS

Experimental alternative	Ca		Mg		K		P	
	mg/kg	%	mg/kg	%	mg/kg	%	mg/kg	%
V_0	4002	100	2117	100	1350	100	800	100
V_1	4723	118	2410	114	1900	140	1180	147
V_2	5450	136	3175	150	1970	146	1505	188
V_3	6517	163	3412	161	2610	193	1725	215
V_4	8672	217	3645	172	2600	193	1665	208

took place proportional by the rise of the waste dose being of 51% for the highest dose (V_4). Values for magnesium content in soil were lower, but the increase is much more significant than for calcium. The lowest experimented waste dose generates an increase of 110% for magnesium content, reaching an increase of 260% for the highest dose.

Influence of the soil treatment on plants

The effects of soil treatment with different doses of waste on the growth process of oat plants are shown in table 4.

The enhance of waste amounts in soil treatment had a beneficial effect on the grains germination pointed out by a higher number of risen oat plants. The increase by 20% of the risen plants number was obtained for the highest dose of administered waste (V_4) on soil. Green oat plants grew taller once with the increase of the waste dose; the plants size was taller by 4 cm (15%) for V_4. At harvest time, the green oat plants were taller, thinner and had a reduced dry matter content for all experimental alternatives in comparison with the control alternative. The decrease of dry matter in green oat plants at harvest time was 13.1% for V_4 compared to V_0. The effect of the soil waste treatment (V_4) on the yield of green oat plants shows a decrease by almost 50% for the dry weight of the harvested green oat plants and by 20% for the fresh weight of the green oat plants. Table 5 shows the influence of soil treatment with different waste doses on the calcium and magnesium uptake by plants and their content in calcium and magnesium at harvest time.

Treating soil with higher waste doses increases the uptake of calcium and magnesium by plant. The increase of calcium concentration in green oat plants took place proportional to the waste dose. The highest waste dose (V_4) determined an increase by 117% of the calcium concentration in plant at harvest time; for the same waste dose, the increase of magnesium content was of 72%. For all the other waste doses in experimental alternatives V_1 - V_3, the uptake of calcium and magnesium by the plant is similar, namely 18 and 14% for V_1, 36 and 50% for V_2, 63 and 61% for V_3 respectively.

Since the oat presents an important uptake capacity for phosphorous and potassium [9], the increase of these characteristics was observed during the treatment. The values in table 5 show a proportional growth of all the macroelements (calcium, magnesium, potassium and phosphorus) content simultaneously with the waste dose, while the plants weight became lower. This fact leads to the conclusion that the soil nitrogen content is low. As a result of the Liebig law, the nitrogen lack was the cause of this weight lowering [10]. The high protein content of oat requires an important nitrogen contribution.

Conclusions

The research shows that soil treatment with this industrial waste has a beneficial effect on soil quality and on the fertility of acid soils. It was established that there is a direct correlation between the increase of the applied waste dose in soil and the neutralization of soil acidity, improving also the content of calcium and magnesium. Once with the increase of waste dose, the improve of magnesium content in soil is more significant than that of the calcium content.

The experimental waste doses had a beneficial effect on grains germination improving the number of risen oat plants. The green oat plants were taller and thinner for all applied waste doses comparative to the control alternative of untreated soil. The uptake of calcium and magnesium by the green oat plants is similar; for all the experimental alternatives, the enhance of the applied waste dose leads to an increase of the calcium and magnesium concentration in the green oat plants at harvest time.

Considering the obtained results, the tested industrial waste can be used in certain doses as amendment and fertilizer for low fertile acid soils.

References

1. RĂDULESCU, H., TAUBERT, L., KISS, A. S., PRINCZ E., STEFANOVITS-BÁNYAI É., J. Serb. Chem. Soc., **72**, nr.6, 2007, p.629

2. TAUBERT, L., RĂDULESCU, H., KISS, A. S., STEFANOVITS-BÁNYAI É., PRINCZ E., Proceedings of the 14th Symposium on Analytical and Environmental Problems, Szeged, Hungary, 2007, p.208

3. KOHN, D., TAUBERT, L., POLICEC, S., ROMÂNU, E., F&S - Filtr. Sep., **12**, nr.4, 1998, p.161

4. TAUBERT, L., POLICEC, S., KOHN, D., Proceedings of the IVth International Symposium "Regional Multidisciplinary Research", Timişoara, România, 1998, p.521

5. TAUBERT, L., Proceedings of the 12th Romanian International Conference on Chemistry and Chemical Engineering, Bucharest, România, 2001, p.201

6. TAUBERT, L., Proceedings of the 9th Symposium on Analytical and Environmental Problems, Szeged, Hungary, 2002, p.41

7. AVARVAREI, I., DAVIDESCU, V., MOCANU, R., GOIAN, M., CARAMETE, C., RUSU, M., Agrochemistry, Ed. Sitech, Craiova, România, 1997, p.48

8. LIXANDRU, GH., CARAMETE, C., HERA, G., MARIN, N., BORLAN, Z., CALANCEA, L., GOIAN, M., RAUTA, C., Agrochemistry, Ed. Didactică şi Pedagogică, Bucureşti, România, 1990, p.21

9. VADÁNYI, M., Részletes Növénytermesztés (Detailed view on the plant growth), Egyetemi Nyomda, Budapest, 1941, p.33

10.KISS, A. S., Nitrogénipari elemzések (Consideration of the nitrogen industry), Müszaki Kiadó, Budapest, 1964, p.318

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