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DOLOMITE AND CALCITE TREATMENTS APPLYING IN MELIORATION OF AN ACIDIC SANDY SOIL

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Abstract

In the Institute of Agricultural Chemistry and Soil Science of Debrecen University in pot experiment, the effect of two carbonate containing amendments are examined on some properties of an acidic humous sandy soil (pH_{H2O}=5.2) originating from Nagykáta. In the two treatments the amendments were granulated dolomite and calcite, the applied quantities were 3 t ha^{-1}. In the amelioration pot experiment all treatments enriched NPK fertilizers taking into account the nutritional requirements of test plant (Phaseolus vulgaris nanus L); it was a *„Yellow-podded - Maxidor" bean.*

On the bases of the first year results, the water management parameters were influenced positively by dolomite and calcite treatments. The water permeability of sandy soils decreased significantly in dolomite treatment. At the same time, the water holding capacity of the soil increased almost equally due to dolomite and lime doses. The pH of the soil increased, the hydrolytic acidity decreased, both under the influence of dolomite and lime, but the soil remained acidic. Among microbiological soil properties the number of total bacteria, the activity of saccharase, urease and dehydrogenase activity increased significantly, especially in the dolomite treatment. The CO_2-production didn't change significantly in the treatments.

The intensive soil management, the application of high fertilizer doses affect negatively on soil reaction (pH), thereby some features of the soil would deteriorate; so the soil acidification affects an increasing proportion of agricultural land. With these results we would like to draw attention to the importance of soil amelioration of acidified soils with natural, carbonate-containing materials.

Key words: dolomite, calcite, acidic sandy soil, water management, chemical, microbiological characteristics of soil

INTRODUCTION

Sustainable agriculture (Velten et al., 2015) is an integral part of sustainable soil use (Oneț et al., 2015), the preservation of our soil, and continuous amelioration of soils with bad qualities to increase soil fertility (Kocsisné et al., 2013).

Increased use of fertilizers and intensive soil use contribute to acidification of soils (Nduwumuremyi, 2013; Horváth, 2019). In Hungary the proportion of acid soil is about 25 % of the agricultural land. Studies prove the beneficial effects of lime and lime containing amendments on the chemical and microbiological soil properties (Zsuposné Oláh, 2002).

Gustavo Spadotti and Carlos Alexandre, 2015, studied the effects of surface lime and silicate treatments on chemical properties of soil, on soybean and corn test plants. Increased the concentration of N, Ca, and Mg

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in the leaves (Kátai et al., 2019), and also increased the seed yield of soybeans. In the experiment of Kovacevic et al., 2017, the dolomite also increased the yield of soybean, the protein content of the seed, and the oil content depending on the dose.

MATERIAL AND METHOD

The pot experiment was set up in 2017 in the Debrecen University, Department of Agrochemistry and Soil Science on acidic sandy soil ($pH_{(H2O)}$ = 5.2) with low humous content (Hu = 0.67 %) from Nyírkáta (Hungary). Every pot had 12 kg soil. Treatments were the same – 3 t ha^{-1} - with dosages of dolomite and $CaCO_3$, separately.

The water content of treatments was in the same level, as the 70 % of the maximum water capacity. The pots were sprinkled in every day to the same mass. The test plant was the yellow pod – Maxidor type bush bean *(Phaseolus vulgaris nanus L.).*

As basic treatment NPK were added to every one kg soil, in form of ammonium nitrate solution (nitrogen), and P_2O_5 and K_2O solution of potassium dihydrogen orthophosphate and potassium sulphate.

Soil samples were taken in the tenth week after the seeds sprouted. The seeds were sowed 27. April in 2017. After the sampling the experiment was liquidated (7. July 2017).

Among the physical parameters of soil the moisture content (Klimes-Szmik, 1962), the water permeability and water holding capacity was measured according to Vér, 1979.

From among the chemical futures the pH of soil was measured in suspension of distilled water and M KCl [$pH_{(H2O)}$; $pH_{(KCl)}$] and the hydrolytic acidity (Filep, 1995), further nitrate nitrogen content and after 14 days incubation the level of nitrate mobilization (Felföldy, 1987) was determined.

Among the microbiological parameters the total numbers of bacteria (in meat soup agar), the number of microscopic fungi (in peptone glucose agar) was determined by plate dilution method according to Szegi, 1979. The further parameters were the soil respiration (Witkamp, 1966), the activities of saccharase enzyme (Frankenberger and Johanson, 1983), urease (Kempers cit. Filep, 1995) and dehydrogenase enzyme (Schinner et al., 1996).

This study aimed to evaluate the effect of improving materials on some physical, chemical and microbiological properties of an acidified sandy soil.

Statistical evaluation (Szűcs, 2002) was done by SPSS 13.0 program. The applied program was the One Way *ANOVA*, with the Duncan[a] – test, which showed the differences between the effects of treatments on significant level of 5 % advantageous offer in agricultural calculating, and correlation (*Pearson*) and regression analyses were taken between the measured soil parameters.

RESULTS AND DISCUSSION

Among the soil water management parameters the moisture content of soil was higher the both dolomite and lime treatments, than in the control. The water permeability of sandy soils decreased significantly in dolomite treatment, while the water holding capacity of the soil increased similarly by the dolomite and lime doses (Table 1).

Table 1

Effects of treatments on same water management parameters of soil

Treatments	Moisture content (%)	Water-permeability (ml 10 sec^{-1})	Water holding Capacity ($n_{m\,\%}$)
Control	10.78a	113.3b	7.32a
Dolomite	15.14b	101.0a	13.65ab
Calcite	14.23b	110.2ab	15.00b
LSD $_{(p \leq 0.05)}$	***1.75***	***10.00***	***6.95***

Regarding the chemical soil properties, soil pH increased slightly in the two amended treatments, but the pH of the soil remained acidic. At the same time, the hydrolytic acidity was reduced, but not significantly. The nitrate N content of the soil increased significantly as a result of the dolomite treatment, the net nitrification after 14 days of incubation increased, but the changes not statistically verified (Table 2).

Table 2

Effects of treatments on same chemical parameters of soil and the extent of the net nitrification

Treatments	$pH_{(H2O)}$	$pH_{(KCl)}$	Hydrolytic acidity (y_1)	Nitrate-N (1) (mg $1000g^{-1}$)	Nitrate-N (2) (mg $1000g^{-1}$)	Net nitrification (mg $1000g^{-1}$)
Control	5.43a	4.20a	12.39a	8.86a	15.46a	6.60a
Dolomite	5.89b	4.46b	10.88a	11.42b	20.44b	9.02a
Calcite	6.01b	4.50b	10.55a	10.18ab	19.43b	9.25a
LSD $_{(p < 0.05)}$	***0.16***	***0.06***	***1.9***	***1.35***	***3.11***	***2.74***

Among the biological properties of the soil, we have determined the total number of bacteria; it has increased by both treatments. In addition to dolomite, the number of bacteria was slightly higher (Table 3).

The number of microscopic fungi decreased in the treatments due to the increasing pH. The CO_2-producation did not change by the treatments.

Table 3

Effects of treatments on same measured microbiological parameters of soil

Treatments	Total number o f bacteria (*10^6 g^{-1} soil)	Total number of fungi (*10^3 g^{-1} soil)	CO_2-production of soil (CO_2 mg 100g^{-1} 10 $days^{-1}$)	Saccharase enzyme (glucose mg 100g^{-1} 24h^{-1})	Urease enzyme (NH_4-N mg 100g $^{-1}$24h^{-1})	Dehydrogenase enzyme (INTF µg g^{-1} 2 h^{-1})
Control	5.14a	89.33b	14.35a	3.43a	19.53a	62.70a
Dolomite	6.23b	69.33a	15.12a	5.39b	42.07b	88.77b
Calcite	5.95ab	60.00a	14.89a	3.92ab	49.16c	88.60b
LSD ***$_{(p < 0.05)}$***	***0.88***	***18.58***	***5.02***	***1.76***	***3.99***	***19.09***

Among the activity of soil enzymes, the urease activity increased to the greatest extent, especially in the calcite treatment. Dehydrogenase activity was also significantly increased, almost the same level in the two treatments. More than doubled the saccharase activity increased, the greatest effect of the two amendments

Correlation analyses *(Pearson)* shows several close correlation among the soil parameters caused by soil improving material. Only a few of the correlations are highlighted, which have proved to be true in the case of lime and dolomite. The correlation coefficient (r) demonstrated a close positive correlation between the water holding capacity of the soil and the total number of bacteria (dolomite series r = 0.833; $CaCO_3$ series r = 0.709) (Fig. 1).

Further close or medium scale correlation was found between changes in hydrolytic acidity of soil and the number of microscopic fungi (dolomite series r = 0.715; $CaCO_3$ series r = 0.616) (Fig. 2).

The nitrate N content of the soil has close correlation some microbial parameters: with the urease activity (dolomite series r = 0.880; $CaCO_3$ series r = 0.876) (Fig. 3), also with total bacteria number (dolomit series r=0.810; $CaCO_3$ series r=0.767) (Fig. 4).

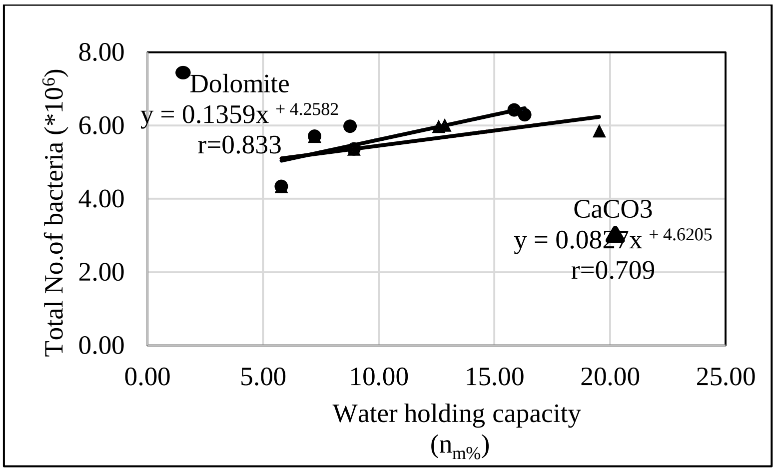

Fig. 1. Correlation between the water holding capacity and the total number of bacteria in the experiment

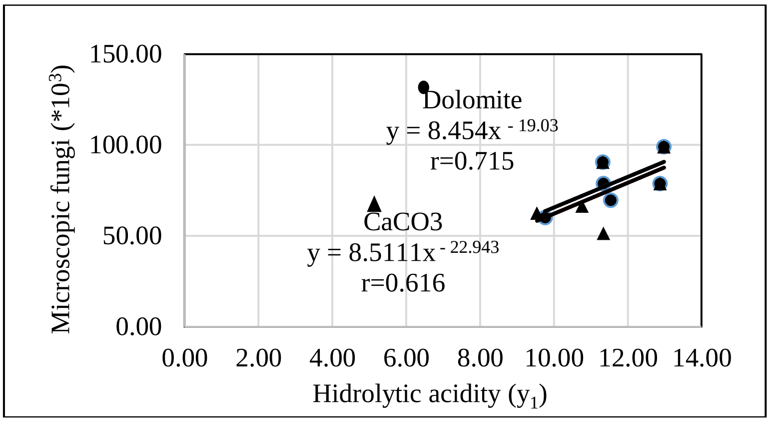

Fig. 2. Correlation between the hydrolytic acidity and number of microscopic fungi in the experiment

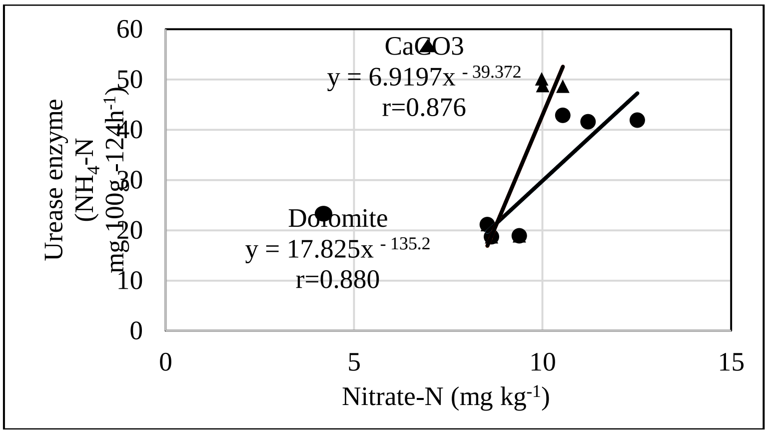

Fig. 3. Correlation between the nitrate –N and the urease activity in the experiment

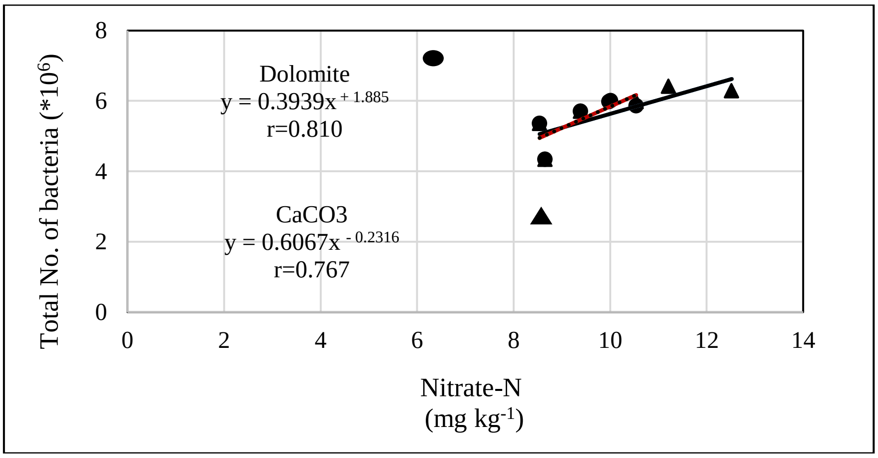

Fig. 4. Correlation between the nitrate –N and the total number of bacteria in the experiment

CONCLUSIONS

This study aimed to evaluate the effect of two improving materials - dolomite (3 t ha^{-1}) and calcite (3 t ha^{-1}) grist's - on some physical, chemical and microbiological properties of an acidified sandy soil. The results in the first year of the experiment have shown the following:

The parameters of water management, e.g. water permeability and water holding capacity were equally influenced positively by treatments;

Soil pH increased by the effect of dolomite and calcite, but due to its strong acidity, the soil stayed in acidic range; the lime increased the pH greater extent, but not significantly;

The hydrolytic acidity (y_1) decreased by the amendments, the soil acidity decreased. The lime application caused significantly higher decrease in this parameter.

The nitrate-N content increased in the amended treatments, improving materials had a positive effect on the nitrate mobilization, similarly the nitrate exploration rate also increased compared to control.

Regarding the microbial parameters, the number of total bacteria, the activity of saccharase enzyme increased significantly in the dolomite treatment. At the same time the number of microscopic fungi decreased significantly in both amended treatments. The activities of urease and dehydrogenase increased in both treatments, but the quantity of CO_2-production was not changed by amendments.

Between the measured soil parameters close correlation was proved in many cases. The pH was close correlation with urease and dehydrogenase activity; the hydrolytic acidity was close negative correlation with the total number of bacteria; the nitrate-N content was close correlation with number of bacteria, and the activity of urease enzyme.

In Hungary about 2.2 million hectares acidic sandy soil can be found. To improving these calcium and magnesium deficient acidic sandy soils, the application of soil amelioration is necessary. In a pot experiment the application of dolomite and calcite as amendments changed the physical, chemical and microbiological soil properties. Parameters of water management, the pH-conditions become more favourable. Due to the favourable environment, the biological activity of soil also positively has changed.

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