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THE EFFECT OF USING ZEOLITE ON SOME CHARACTERISTICS OF SANDY SOIL AND ON THE AMOUNT OF THE TEST PLANT BIOMASS

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Abstract. *Different doses (5; 10, 15; 20 t ha $^{-1}$) of zeolite were studied on humous sand soil, on some soil physical, chemical, microbial characteristics and on the biomass of a test plant ((Lolium perenne L.). The zeolite can have a positive impact on properties of weak soil fertility and can exert advantageous influence with more complex changes of soil characteristics. In terms of efficiency, to use the 15 and 20 t ha^{-1} doses can be recommended. The use of zeolite as soil natural amendment can safety inserted into a sustainable land use system.*

Keywords: zeolite, humous sand, soil characteristics, plant biomass

1. Introduction

The zeolite mineral association is one of the most used and researched clay minerals which can significantly contribute to the preservation of soil fertility [1, 2].

Zeolites are aluminium-silicates, the two most important of their components the clinoptilolite- and mordenite- tectosilicates. By properties zeolites are applied in agriculture on field of the horticulture and landscape architecture, communal waste- [3, 4] as well as in the field of water management [5]. As a fertilizer, it has an advantageous effect on soil pH (it reduces the soil acidity) and the availability of microelements [6]. It enhances water uptake by plants and the water management of soils [7]. In agriculture are used as amendments of soil improvement, as well as component in gardening soil mixtures, and excipient in compost productions [8]. The zeolites are applied to seedlings, rooting and intensive horticulture [9]. They have a positive effect on nutrient-supplying system, and development of plants [10].

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Due to these reasons above experiments were carried out with zeolite, and we studied the effect of zeolite on some soil characteristics on humous, acidic sand soil, and how it influences the amount of test plant biomass.

2. Material and methods

The experiment was set up in the greenhouse of Institute of Agricultural Chemistry and Soil Science. We examined the effect of increased dose of zeolite on some physical, chemical properties and some microbial features of an sandy soil and on the biomass of a test plant was measured in controlled conditions.

The soil type of experiment was: humous sand soil type of Pallag. The pH of the cultivated layers was weakly acidic (pH_{H2O} 6.52) and low in humus (Hu%=1.6%).

The zeolite treatments were set up in year 2014 in three kg, bottom perforated pots. Zeolite treatments are shown in the Table 1.

Table 1) Treatments and the applied doses of the pot experiment (Debrecen, Hungary, 2014)

Number of treatments	Treatments	Doses (t ha^{-1})
0	Control	0
1	Small-dose	5
2	Middle-dose	10
3	Middle-large dose	15
4	Large dose	20

Water content of treatments was kept on the same level, which is 70% of the maximum water-holding capacity. The pots were watered in every day to the same mass. Basic treatments 50 mg nitrogen – as $Ca(NO_3)_2$ solution – and 50 mg P_2O_5 and 50 mg K_2O as potassium dihydrogen orthophosphate and potassium sulphate solution were given to every pot.

Among the soil physical parameters the soil moisture content [11], the water holding – and permeability capacity were measured [12]. Among the chemical parameters the pH in suspension of distilled water and M KCl [$pH_{(H2O)}$; $pH_{(KCl)}$] [13], to concern to the soil nutrient content the nitrate nitrogen-, the ammonium lactate-acetate soluble phosphate and potassium content of soil were determined [14]. Among the microbiological parameters the total countable numbers of bacteria (in meat soup agar), the number of microscopic fungi (in peptone glucose agar) was measured by plate dilution method [15]. The soil respiration [16], the activities of phosphatase [17], dehydrogenase enzyme [18] were determined.

As test plant the perennial rye grass *(Lolium perenne L.)* was used, cutted in twice a year. Plant biomass was given in g pot^{-1} dry mass basis.

By statistical analysis F-test analysis of variance was performed at p=5% level. The applied method was the Duncan – test. We labeled the distinctnesses between

the treatments with the little letters of the alphabet in the tables. Statistical calculations by SPSS 13.0 for Windows and Microsoft Office Excel programs were carried out.

3. Results

The soil physical properties will be shown firstly, followed by the results of pH and available nutrient content and the microbiological parameters, finally the biomass quantity of the perennial ryegrass as test plant.

Among the physical soil properties (Table 2.) the moisture content chanced between 17.71 and 19.18% due to the controlled circumstances, it proved satisfactory in the pot experiment.

Based on our results, along the one year application of increasing zeolite doses did not influence on the water holding capacity and the water permeability of soil significantly. But it can be stated that the water holding capacity slightly increased in the soil, at the same time the water permeability decreased in all treatments compared to the control.

Table 2) The effect of zeoilte on some soil water management properties (Debrecen, Hungary, 2014)

Number of treatments	Moisture content (%)	Water holding capacity (%)	Water permeability (ml 10 sec^{-1})
0	17.71 a	17.00 a	63.93 a
1	18.07 a	17.70 a	52.67 a
2	18.80 a	17.48 a	56.33 a
3	17.88 a	17.57 a	61.27 a
4	19.18 a	18.06 a	58.40 a

The soil pH – measured in distilled water - changed (Table 3.) favourably in some treatments. The treatment of 10 and 20 t ha^{-1}-the soil pH increaced, so positive change was caused in the pH. The soil pH in KCl-suspension increased in all treatments and in the treatment of the 5 t ha^{-1} dose the effect of zeolite was significantly positive.

Table 3) The effect of zeolite on some chemical proporties of soil (Debrecen, Hungary, 2014)

Number of treatment	$pH_{(H2O)}$	$pH_{(KCl)}$	Nitrate-N (mg 1000 g^{-1})	AL-P_2O_5 (mg 1000 g^{-1})	AL-K_2O (mg 1000 g^{-1})
0	6.52 a	5.29 a	6.18 a	267.58 a	266.25 a
1	6.61 a	5.43 b	5.65 a	271.05 a	294.77 a
2	6.85 b	5.39 ab	6.88 a	273.43 a	281.11 a
3	6.55 a	5.30 a	10.13 b	331.2 b	301.76 a
4	6.68 ab	5.38 ab	10.22 b	317.63 b	372.04 b

The available nutrient content of the sandy soil (Table 3.) proved to be well stocked. The treatments of the zeolite doses usually increased the nitrate-N content, the AL-soluble phosphorus content and the AL-soluble potassium content in soil. The treatments in the 15 és 20 t ha^{-1} doses of zeolite the increase were experience significant positively, except for potassium content the treatments in 15 t ha^{-1}.

Influence of zeolite treatments soil microbiological parameters varying degrees changed (Table 4.). The number of total bacteria increased significantly in the treatments of 5, 10, 15 t ha^{-1}, also the activity of phosphatase enzyme in the 15 and 20 t ha^{-1} treatments.

Also slightly increased the number of microscopic fungi and activity of dehydrogenase enzyme in all treatments. Among the effect of different doses there was no difference. The soil respiration also increased slightly in the applied 15 and 20 t ha^{-1} zeolite doses, but it can not be proved statistically.

Table 4) The effect of zeolite on some microbial proporties of soil (Debrecen, Hungary, 2014)

No. of treat-ment	Total number of bacteria (*10^6 g^{-1} soil)	Microscopic fungi (*10^3 g^{-1} soil)	Soil respiration (CO_2 mg 100 g^{-1} 10 days)	Phosphatase enzyme (mg P_2O_5 100g^{-1} $2h^{-1}$)	Dehydrogenase enzyme (INTF µg g^{-1} $2h^{-1}$)
0	4.67 a	50.47 a	5.89 a	2.38 a	33.00 a
1	5.54 ab	58.70 a	5.96 a	2.51 a	33.73 a
2	6.86 b	64.13 a	5.67 a	1.99 a	37.80 a
3	5.64 ab	65.47 a	6.09 a	4.08 b	36.53 a
4	5.22 a	55.95 a	6.21 a	5.95 c	36.53 a

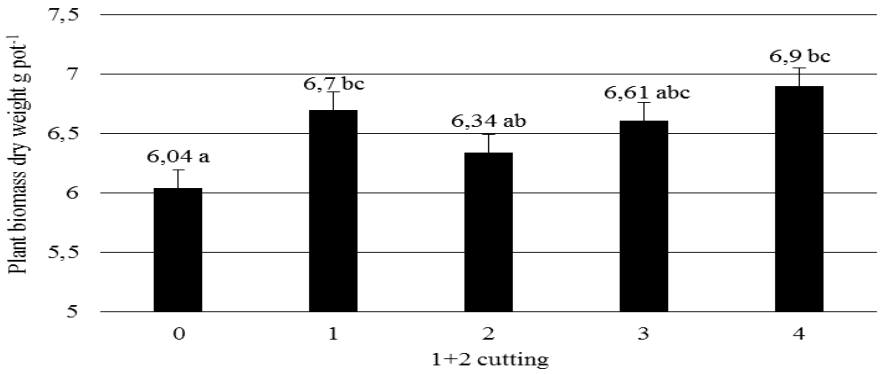

Fig. 1. The effect of zeolite on the biomass of the test plant – perennial ryegrass (*Lolium perenne, L.)* (Debrecen, Hungary, 2014)

In the season, the total quantity of ryegrass was determined on the based of the sum of two cuttings (Figure 1.). The results showed differences between the control and the treatments.

The grass mass increassed even in the treatment of 5 t ha^{-1} dose, but the largest increase was measured in the pots treated by 20 t ha^{-1} zeolite. The biomass of the test plant in both treatments was increased significantly, its quantity was larger by 5-14%, than it was in the control pots.

4. Conclusion

The water holding capacity slightly - not significantly - increased, at the same time the water permeability decreased in all zeolite treated soil compared to the control.

The soil acidity decreased by the effect of zeolite, the soil nitrate-N and available phosphorus content increased significantly in the 15; 20 t ha^{-1} doses of zeolite. The AL-soluble potassium also increased in the large dose of treatment.

Among the microbiological properties of soil the total number of bacteria was the most sensitive parameter and the activity of phosphatase enzyme increased significantly in the 15; 20 t ha^{-1} treatments. Lower effect of zeolite was measured on the quantity change of microscopic fungi and dehydrogenase activity. The values of soil respiration did not changed significantly in the treatments.

Based on the one-year results the total plant biomass quantity of ryegrass test plant was more by 5-14%, than it was in the control pots.

The zeolite as a natural material safety fits into the sustainable land use system, the largest, 20 t ha^{-1} dose of zeolite can be recommended as the most efficient dose on sand soil.

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