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Nutritive improvement possibilities in pasture production using ammonia-loaded zeolite

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In this study the influence of ammonia-loaded zeolite on growth of grass and legume species, important for forage production, was investigated. Zeolite is traditionally used in agriculture as soil conditioner and as nitrogen retaining medium for nitrogen fertilizing improvements. Our pot experiment was carried out to investigate impact of ammonia loaded zeolite on growth and yield of Italian ryegrass (*Lolium multiflorum* Lam.) and red clover (*Trifolium pratense* L.) under controlled conditions. The experiment was conducted on two types of soil (*Planosol* and *Dystric Cambisol*) and it included four fertilizing treatments: control; soil with the addition of zeolite; soil with the addition of ammonia-loaded zeolite and nitrogen application by mineral fertilizer; all in 4 replications. The results suggest that different fertilizing treatments could affect crop yield.

Introduction

Zeolites structural features make them attractive hosts for a variety of molecules and candidate these materials for many different applications. The structure of natural zeolite clinoptilolite is ideal for sorption and ion exchange processes. Our experiment was conducted with a natural zeolitic tuff (from “Zlatokop” mine in south Serbia, containing ~70wt. % of clinoptilolite) and ammonia-loaded zeolite (formed by binding of ammonia ions from aqueous solution). It has been reported that zeolites, with their specific selectivity for ammonium, can take up this specific cation from either farmyard manure, composts, or ammonium-bearing fertilizers, thereby reducing losses of nitrogen to the environment. The application of farmyard manure (FYM) on pastures have several advantages. It is a low-cost and sustainable organic fertilizer but the content of ammonia during the fermentation process can be significantly decreased due to volatilization. The purpose of this experiment was to investigate how much ammonia loaded on zeolite is available to plants and how it affects crop yield.

Methods

Soil collected at the sites Varna and Vlasina was homogenized whereas stones and roots were removed. The pots were filed with 2 kg of air-dried soil and the seeds was sown on 17 March 2014. at a rate of 50 seeds per pot. Germination rate of red clover was influenced by soil low pH value so the experiment was repeated on 02. April 2014., but this time soil pH value was adjusted and mineral forms of plant nutrients (other than nitrogen) were added.

The experiments carried out in growth chamber included four different treatments:

a) soil (control);
b) soil+zeolite CLI (10 g kg^{-1});
c) soil+ammonia-loaded zeolite CLI-AM (10 g kg^{-1} equivalent to nitrogen application of 100 kg ha^{-1} N);
d) nitrogen application by mineral fertilizer Calcium ammonium nitrate CAN (100 kg ha^{-1} N, CAN contains 27% nitrogen).

Conditions in growth chamber were: average temperature 23°C, 12 hours of irradiance and soil moisture was kept at 60% of soil field capacity.
Plants were cut back four times in all the individual experimental pots, about 2-3 cm above soil level, approximately every 25th day.
Plant tissue was examined for changes in weight and the data were analysed by analysis of variance (ANOVA) using statistical programme R (version i386 3.1.1). Posthoc Tukey’s significant difference test at $p < 0.05$ was applied.

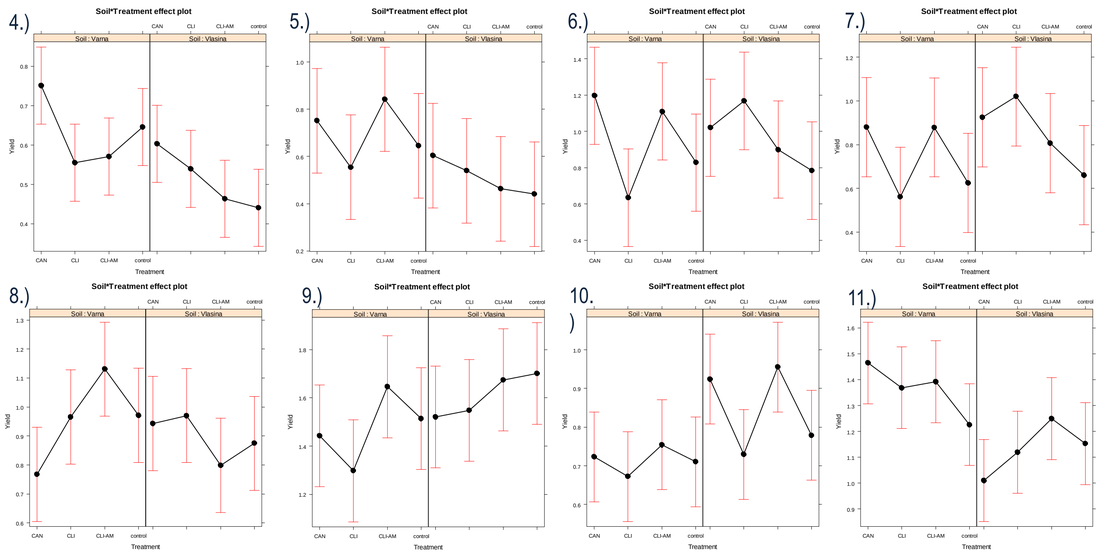
Figure 1-3. Experiment setup.

Table 1. Soil properties

Soil	Textural class	Chemical properties					
		pH		AL-P_2O_5 (mg kg^{-1})	AL-K_2O (mg kg^{-1})	Total C (%)	Total N (%)
		in H_2O	in $CaCl_2$				
Varna	Sandy loam	5.73	5.07	19.8	115.1	1.37	0.16
Vlasina	Clay loam	5.10	4.18	6.7	63.0	1.10	0.096

Results

The difference in yield on two soils was statistically significant for the first two cuts on Italian ryegrass and the second two cuts of red clover. It is important to keep in mind that the soil used in red clover experiment was amended and that it’s pH value was modified from 5.1 to 6.4 while the other plant nutrients were added before the sowing. That could explain why was the yield higher on less productive soil. According to the Tukey’s test the yield of Italian ryegrass was higher on Varna soil in the 1st two cuts.



Figures 1 – 8: Yield per pot mean values with 95% confidence intervals (g). 1 – 4: 1st to 4th cut respectively Italian ryegrass; 5 – 8: 1st to 4th cut respectively Red clover.

High variability of the data caused by uneven germination rate could somewhat diminish the power of the test, but one of our goals was to investigate weather the treatments have an influence on the germination of Italian ryegrass and red clover.

For It. ryegrass the effect of the treatment was significant in the first cut when p-value was 0.01. The highest yielding treatment was CAN. It is interesting that in third cut there is significant effect of interaction. It is possible that CLI slightly raised pH value of less productive soil, while CLI-AM was almost as effective as CAN on soil with higher pH value. If we compare total yield per pot we can observe significant difference (p-values are 0.04) between soils and between treatments.
Treatment had conditionally significant effect on the total yield of red clover (p-value 0.07). At $p < 0.10$ difference in total yield was observed between CLI and CLI-AM. Some of the nutrients could have been bonded in treatment CLI, while CLI-AM had a positive effect on total yield.

Figure 12. Italian ryegrass in growth chamber

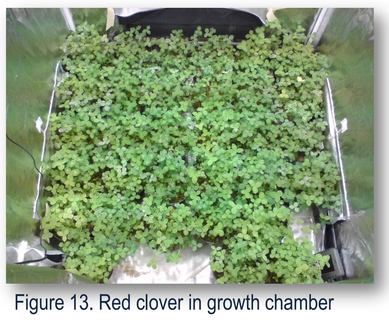


Figure 13. Red clover in growth chamber

Conclusion

The results suggest that plants may have a good response if clinoptilolite is used as a nitrogen fertilizer carrier on some types of soil. Further research is needed for the determination in which conditions the application of zeolite is optimal. The next stage of our research will be testing the results in field conditions.

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