ENHANCING THE ORGANOMINERAL FERTILIZER USE EFFICIENCY IN BINARY FORAGE CROP

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ABSTRACT

The aim of this research was to determine the effect of organomineral fertilizer based on farmyard manure enriched with zeolitic tuff on production and quality traits of binary crop mixture (triticale and field pea) in field conditions. Since the organic fertilizers are very important for sustainable forage production, in this work, zeolitic tuff was used as a binding agent for ammonia released from cattle manure. It has been shown previously that the addition of 10 wt. % zeolite from Zlatokop deposit, Vranjska Banja, containing 70 % of clinoptilolite, to fresh cattle manure increases retention of ammonia by 90 % in comparison to the system without zeolite.

In this study, sowing of triticale and field peawas done in the autumn 2013 and 2014, and the research included three fertilization treatments: a) pure manure; b) manure+zeolite and c) control (without fertilization).Type of fertilization had no significant effect on dry matter yield, but, has significant effect on enhanced nutrient supply (manure fertilization) in binary mixture, in terms of increasing protein content and some other quality traits.

Key words: cattle manure, herbage yield, mixture crop, quality traits, zeolite.

INTRODUCTION

Ammonia (NH_3) emission from beef cattle feed yard manure results in losses of nitrogen (N), which may negatively affect air, soil, and water quality. The magnitude and rate of NH_3 volatilization from feed yards partially depends on the amount of urinary urea excreted and dissociation of ammonium (NH_4^+) into NH_3 following urea hydrolysis [1]. The application of farmyard manure (FYM) did not have a significant effect on forage quality inpermanent grassland, whereas chemical composition was significantly affected by different cuts and experimental years [2]. Based on the results, grassland may have a good dry matter yield response if FYM is used as a fertilizer, while the effect on forage qualitymay be much weaker.

Zeolite clinoptilolite is a naturally occurring, porous aluminosilicate mineral that can adsorb and sequester cations within its negatively charged framework structure. Zeolite has been used to mitigate NH_3 losses and improve fertilizer value of compost, sewage sludge, and manure in livestock barns [1]; however, few studies have evaluated its efficacy on open-lot beef cattle feedyards. Zeolite application to open surfaces could be a practical and cost-effective means of reducing NH_3 losses. Nitrogen fertilizer containing clinoptilolite, applied after resumption of growth increased the amount of N-NH_4, N-NO_3 and total mineral nitrogen in the arable layer compared with the plots applied with KAN (27% N)[3].

Effects of zeolite application rate [0.5 % to 10.0 % of manure dry matter (DM)] on sorption and desorption characteristics in a manure/artificial urine matrix were highly variable but tended to be proportional to zeolite application rate: as little as 0.5% zeolite increased NH_4^+-N recovery by up to 19 %. In flow-through chamber studies, higher rates of zeolite did not reduce cumulative NH_3 emissions, as 1.0 % zeolite reduced cumulative NH_3 emission by

42 % and 5.0 % zeolite reduced N losses by only 18 % compared to unamended manure [1]. Surface application of zeolite has potential for mitigating feedyard NH_3 losses, but specific zeolite properties influenced its effectiveness.

The objective of this study was to investigate and launch the sustainable ammonia source for forage crop mixture, which is based on natural zeolite mined from “Zlatokop” in south Serbia. The zeolite effects on herbage yield and quality traits on field pea and triticale binary crop were also evaluated. Understanding the influence of organomineral fertilizer on herbage yield and protein content can be used to improve N use efficiencies in the field.

EXPERIMENTAL

Field plots (5 m x 2 m) were established on Planosol (pseudogley) [4] soil type in the vicinity of Šabac (44°40’40’’N 19°39’05’’E, 123 m a.s.l.), Serbia. The field trials were established in seasons 2013/14 and 2014/2015, included three fertilization treatments: a) pure manure (30 t ha^{-1}); b) manure+zeolite (30 t ha^{-1}+10 wt. % zeolite); c) control applied on mixture field pea+triticale. The zeolitic tuff (Zlatokop deposit, Vranjska Banja; containing 70 % of clinoptilolite: $Ca_{1.6}Mg_{0.7}K_{0.7}Na_{0.3}Al_{5.5}Si_{26}O_{72}\cdot 23H_2O$, grain size in the range 0.063-0.1 mm) was used as the additive to manure.

Experimental plan was completely randomized block design, set up in four repetitions with plots size of 10 m^2 and seeding rate of 100 kg ha^{-1} for field pea Javor and 40 kg ha^{-1} for triticale KG Bingo. Autumn tillage was done at depth of 25 cm, followed by a fine seedbed preparation and land rolling after sowing. Prior to application, fresh cattle manure was homogenously mixed with the natural zeolite – clinoptilolite and fermented during 3 months. The treatments with manure and a mixture zeolite+manure were applied in autumn.

For determination of pH, in H_2O and $CaCl_2$, 25 mL of double distilled water or 25 mL 0.01 mol ($CaCl_2$) L^{-1} aqueous solutions were added to 10 g of soil and stirred for 30 min. The pH values were measured directly in the suspensions (Iskra MA 5730). Available phosphorus (P_2O_5) and potassium (K_2O) were extracted according to the Egner-Riehm method [5] and determined with a colourimeter (Iskra MA 9507) and an atomic absorption spectrophotometer (Shimadzu AA - 7000), respectively. Total organic carbon content in the soil was determined by potassium dichromate oxidation using Simakov’s modification of the Turin method [6]. Total nitrogen content was determined by the Kjeldahl semimicro-method. The trial was carried out in natural water conditions (no irrigation) and main properties of Planosol soil type were shown in Table 1.

Table 1. Chemical properties of soil.

Soil type	pH		Al-P_2O_5 mg kg^{-1}	Al-K_2O mg kg^{-1}	Total C %	Total N %
	H_2O	$CaCl_2$				
Silty clay loam	5.73	5.07	19.8	115.1	1.37	0.16

Prior to manure fermentation, available element amounts of fresh manure were determined (Table 2).

Table 2. Available element amounts in manure (mg kg^{-1}) ± SD.

	N	P_2O_5	K_2O
Average ± SD	277.9 ± 27.8	2009.5 ± 366.0	1322 ± 285.7

The plots were harvested in May and the dry matter (DM) of the harvests was measured. The dry matter was formed on the basis of 1 kg of fresh matter, which was dried in an oven at a temperature of 60 °C. Crude protein (CP = N x 6.25) was measured by Kjeldahl analysis on a BUCHI Distillation unit for nitrogen determination [7]. Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined as filter residue weights after boiling forage samples for 1 h in beakers either in neutral detergent solution or in acid detergent solution, according ref [8]. Total DM yield and DM quality were analyzed by analysis of variance (ANOVA) and LSD test (statistical significance was determined at $p<0.05$), in order to recognize significant effects of fertilization treatments.

RESULTS AND DISCUSSION

Adoption of new management techniques, such as clinoptilolite zeolite (CZ) utilization has attracted much attention in the fertilizer industry [9]. Accordingly, the aim of this study is to evaluate: if CZ, acting as an inert material, when applied to the soil with manure, might improve the selected soil properties, dry matter, nutrient uptake, and consequently, forage quality on field pea and triticale cultivation. A significant effect of different fertilizer treatments on chemical composition and quality of herbage was found. The both fertilizer treatments had a favourable effect on the proportion of crude protein in DM (Table 3), confirmed in first and second experimental years. In the second experimental year the determined crude protein (CP) values were higher than in the first year (in average 17.85 and 15.29 %, respectively). Unlike crude protein content, the use of different fertilizer treatments did not affect FM and DM yield in both years. Consistent with the effect of manure on CP, there was significant effect on crude fibers and nitrogen free extracts in first experimental year, but without noticed effect in second year. The results do not show any significant differences in ADF and NDF content among the treatments.

According to an earlier study [10], proper N fertilization of forage crops generally increases CP. However, the effect of N fertilization on NDF and ADF is variable. Higher N rates tended to increase the NDF concentrations of the plants in wetter years resulting from change in the leaf:stem ratio in favour of less digestible stems [11]. In contrast, Coleman et al. [12] reported that higher N rates provided a delayed plant maturity for later harvests and in turn increased total plant digestibility.

Table 3. Forage (FM) and dry matter (DM) yield (t ha^{-1}) and quality traits of binary mixture crop (triticale and field pea) in two vegetation seasons.

treatments	FM yield	DM yield	CP	CF	NFE	NDF	ADF
			2013/2014				
Control	14.30	2.86	14.59	30.21	38.44	57.3	36.9
Manure	15.84	2.69	19.68	26.07	36.82	49.8	34.1
M+Z	14.12	2.26	19.27	31.55	31.20	52.7	37.9
LSD 0.05	**NS**	**NS**	**4.13**	**3.14**	**5.49**	**NS**	**NS**
			2014/2015				
Control	9.18	1.53	13.22	29.14	38.19	47.3	36.8
Manure	11.63	1.66	16.54	31.66	37.05	49.5	37.1
M+Z	13.68	1.71	16.10	31.17	36.84	46.7	38.8
LSD 0.05	**NS**	**NS**	**2.64**	**NS**	**NS**	**NS**	**NS**

FM – fresh matter (t ha^{-1}),DM – dry matter (t ha^{-1}), CP – crude proteins (% DM), CF- crude fibers (% DM), NFE – Nitrogen free extracts (% DM), NDF - – neutral detergent fibers (%),ADF - acid detergent fibers (%)

The significant effect of the treatments having CZ on protein concentration, in uptake and use efficiency, suggests that CZ incorporated with manure can reduce NH_3 loss, triggering the formation of NH_4 + and NO_3 - over ammonia and increase crop uptake.

In enhanced nutrient supply by manure, the most pronounced effect of different nutrition was on crude protein content, but irrespective of the fertilizer treatment *id est*, without significant effect of CZ addition. It appears that the greatest and most significant response of enhanced nutrient supply in binary crop, in terms of increasing crude protein content, results from the stimulation of field pea development, as a principal beneficiary in mixture of N sources.

CONCLUSION

Treatment with clinoptilolite could improve N uptake and use efficiency in the forage crop tested. The manure application does not significantly affects theforage yield in both experimental years. Further studies are needed to evaluate effects of repeated zeolite application and cost:benefit ratios of zeolite application at commercial crop productions.

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