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THE EFFECT OF VARIOUS SYSTEMS OF MINERAL FERTILIZATION ON THE ACIDIFICATION OF BROWN SOIL FORMED FROM LOESS

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A b s t r a c t. The research pertaining to the acidification of brown soil formed from loess, with the grain-size distribution of clayey silt, was carried out in the years 1982-85 and 1986-89 on a permanent fertilization field in the area of Rzeszów Submountaine Region. In the experiment carried out in the years 1982-85 a differentiated mineral NPK fertilization was applied on the background of constant fertilization with farmyard manure in the dose of 25 t/ha. In the years 1986-89 two experiments were carried out, in which also differentiated mineral fertilization against the background of constant fertilizing with magnesium and liming was applied. The experiment was carried out on an acid soil (1982-85) and very acid one (1986-89). The crop rotation in both the experiments was similar; the differences pertained only to the variety of fodder plant. In the result of a 4-year long intensive cultivation of plants in the crop rotation and differentiated mineral fertilization on the background of applying the remaining fertilizers, the soil reaction of very acid soil changed for acid while that of acid soil changed for worse. The increase of the pH value was accompanied by the drop of hydrolytic acidity and inversely.

K e y w o r d s: NPK fertilization, soil acidification, brown loessial soil

INTRODUCTION

The examination of the effects of fertlizing consists, among others, in the evaluation of changes occurring in the soil environment [1-12]. In the agricultural literature one can find many works, in which the effect of organic and mineral fertilization on the changes of soil properties after several [1,7], a dozen or so [1-4,9], or tens of years [6,8,10] of carrying out the research, and especially of static fertilization experiments are discussed. Long-term fertilization experiments supply us with valuable results pertaining to the soil degradation as the result of constant application of mineral fertilizers only.

The negative effect of the application of mineral fertilizers is prevented by liming and fertilization with farmyard manure [3-6]. Liming and organic fertilization is especially important in light textured soils [1,7]. Heavy textured soils, in general more humic ones, prove much more degradation resistance [2].

The aim of the present research was to determine the effect of the differentiated mineral NPK fertilization on the background of constant fertilization with farmyard manure, magnesium and magnesium combined with liming on the reaction and hydrolytic acidity of the acidified brown soil formed from loess.

MATERIALS

The research was carried out on the basis of 3 experiments located on a permanent fertilization field in the area of Rzeszów Submountaine Region. In these experiments various systems of plant fertilization were applied.

In the experiment I, which was carried out in the years 1982-85, a differentiated mineral NPK fertilization was applied on the background of the constant dose of farmyard manure

(25 t/ha). In the years 1986-89 two experiments were carried out, in which also a differentiated mineral NPK fertilization on the background of constant magnesium fertilization was applied (experiment II) and a differentiated mineral NPK fertilization on the background of constant fertilization with magnesium combined with liming - 4 t CaO/ha (experiment III). Soil on which experiment I was carried out in the years 1982-85 was of acid reaction. It had high content of available phosphorus and magnesium and medium potassium content. The experiments were carried out in the years 1986-89 on a very acid soil with low content of available P and K, and medium content of Mg. The crop rotation in the experiments carried out in the years 1986-89 was similar, only instead of the fodder sunflower - fodder cabbage was cultivated. Mineral NPK fertilization under the remaining plants was identical.

In these experiments 13 fertilization objects were compared, in which the basic level of mineral fertilization ($N_1P_1K_1$) was the following:

- potatoes (Atol variety); N-120 kg,P_2O_5 - 100 kg, K_2O-160 kg/ha/year;
- spring barley (Diva); N-80 kg, P_2O_5 - 100 kg, K_2O-120 kg/ha/year;
- fodder sunflower (Iregi); N-100 kg, P_2O_5 - 80 kg, K_2O-120 kg/ha/year;
- winter wheat (Emika); N-100 kg, P_2O_5 - 90 kg, K_2O-100 kg/ha/year;
- fodder cabbage (Puławska zielona); N-120 kg, P_2O_5-60 kg, K_2O-100 kg/ha/year.

In the experiments II and III magnesium was applied in the doses of 40 kg Mg/ha/year under potatoes, spring barley and winter wheat and 120 kg MgO/ha/year under the fodder cabbage in the form of magnesium sulphate. Nitrogen was applied in the form of ammonium nitrate, phosphorus in the form of triple superphosphate and potassium in the form of potassium salt (57 %). Lime, in the amount of 4 t CaO/ha was applied in the form of burnt lime (85 %).

Each year, after the harvesting of crop, soil samples were taken from A_1 level of the subsequent fertilization objects. Hydrolytic acidity in the extract of calcium acetate was determined as well as pH in 1 mol KCl dm^{-3}. The results of the analyses of the hydrolytic acidity and pH were statistically worked out calculating the LSD according to Dunnet to compare the average hydrolytic acidity and pH from the subsequent fertilization objects after 4 years of plant cultivation and fertilization with the initial values (those from the time before starting the experiment).

RESULTS

In Table 1, the results of the research pertaining to the reaction and hydrolytic acidity of soils depending on the mineral NPK fertilization against the background of a constant dose of farm yard manure, magnesium and magnesium combined with liming in 4-year long crop rotation.

In the years 1982-85 the reaction of soil fertilized with differentiated doses of mineral fertilizers against the background of a constant dose of farm manure decreased a little, especially under the influence of the increasing fertilization with nitrogen and potassium. Only in the object without NPK fertilization, the pH values increased by 0.3 units under the influence of the applied farm manure in comparison to the pH of soil before starting the experiment.

In the years 1986-89 the soil reaction, under the influence of NPK fertilization against the background of constant fertilization with magnesium, increased a bit in the majority of fertilization objects. However, in the objects without NPK, potassium or nitrogen and with the increased dose of phosphorus, the pH of soil increased from 0.69 to 0.9 units.

The applied liming combined with magnesium against the background of the differentiated NPK fertilization, increased the pH values in all the fertilization objects. The increase of the pH of soil was especially distinct in the objects without potassium, without nitrogen and with the increased dose of phosphorus. The lowest pH values were noted in the objects with the highest dose of nitrogen against the background of constant PK fertilization, potassium against the background of constant NP and NPK fertilizations at the constant N:P:K ratios.

Table 1. The effect of NPK fertilization on reaction (pH in 1 mol KCl dm^{-3}) and hydrolytic acidity (Hh - mmol H^+/kg soil) of brown soil formed from loess, on the background of permanent FYM doses, magnesium and magnesium + liming

Fertilization objects	Experiment I NPK+FYM		Experiment II NPK+Mg		Experiment III NPK+Mg+Ca	
	pH	Hh	pH	Hh	pH	Hh
			Nitrogen fertilization on the background of constant PK			
$N_0P_1K_1$	4.51	45.5	4.61	43.5	5.31	34.5
$N_{0.5}P_1K_1$	4.38	45.6	4.58	43.7	5.20	35.2
$N_1P_1K_1$	4.22	45.8	4.57	45.4	5.07	35.7
$N_{1.5}P_1K_1$	4.12	46.1	4.23	47.0	4.92	36.0
			Phosphorus fertilization on the background of constant NK			
$P_0N_1K_1$	4.40	45.9	4.50	44.6	5.19	30.4
$P_{0.5}N_1K_1$	4.41	45.9	4.49	46.5	5.30	35.6
$P_1N_1K_1$	4.22	45.8	4.57	45.4	5.07	35.7
$P_{1.5}N_1K_1$	4.34	45.5	4.77	45.1	5.36	35.5
			Potassium fertilization on the background of constant NP			
$K_0N_1P_1$	4.51	43.7	4.80	40.9	5.44	38.2
$K_{0.5}N_1P_1$	4.28	45.7	4.69	41.8	5.21	34.8
$K_1N_1P_1$	4.22	45.8	4.57	45.4	5.07	35.7
$K_{1.5}N_1P_1$	4.13	46.0	4.55	45.6	4.81	36.9
			NPK fertilization at a constant N:P:K ratio			
$N_0P_0K_0$	5.00	35.8	4.02	46.1	5.21	33.2
$N_{0.5}P_{0.5}K_{0.5}$	4.60	42.1	4.42	45.0	5.20	34.4
$N_1P_1K_1$	4.22	45.8	4.57	45.4	5.07	35.7
$N_{1.5}P_{1.5}K_{1.5}$	4.14	46.0	4.34	47.1	4.57	40.2
Before setting-up the experiment	4.70	48.9	3.92	48.75	3.92	48.75
LSD at P=0.05	0.4	5.1	0.4	6.0	0.7	10.2

The hydrolytic acidity decreased a little comparing to the initial value in the experiments with the differentiated mineral NPK fertilization against the background of constant dose of farm manure and magnesium. However, a distinct decrease of hydrolytic acidity was noted in the experiment on the limed soil fertilized with NPK and the constant dose of magnesium. The hydrolytic acidity was reversely proportional to the pH value of soil at the increasing nitrogen and potassium fertilization and at the proportionally increasing NPK. Only under the influence of the increasing fertilization with phosphorus against the background of the constant fertilization with the remaining components this dependence was not that distinct.

DISCUSSION

The application of liming combined with the mineral NPK+Mg fertilization significantly decreased the acidification of soil in the 4-year long crop rotation. These changes were especially distinct in the soils: without the fertilization with potassium, nitrogen, and NPK. Moskal *et al.* [7] and Gajek *et al.* [3] also noted a favourable effect of liming combined with mineral fertilization on the reaction and hydrolytic acidity of soil.

The increasing mineral fertilization with nitrogen and potassium, independently of the way of fertilization, increased the acidification of soil which manifested with the drop of pH value and the increase in hydrolytic acidity. The application of the mineral fertilization, and especially nitrogen-potassium one adds to the acidification of soil [1,2,5,7,9, 10,12]. Adamus *et al.* [1] noted the increase in the acidification of sandy soil fertilized during the 16 years only with mineral fertilizers. Dechnik *et al.* [2] noted still larger increase of loess soil acidification as the result of 17 years long fertilization with nitrogen in comparison to the acidification caused by potassium fertilization. The influence of mineral fertilization on the acidification of soil is larger in the light textured soils [1,7,8,12] than in heavier and containing more organic matter soils [2,9,10]. In my own research, mineral NPK fertilization was applied against the background of farm manure and magnesium doses, or magnesium combined with liming. Most probably, a favourable interaction between the NPK mineral fertilization and the magnesium one occurred, which increased a little the value of the pH of soil and decreased the hydrolytic acidity of soil.

Wojnowska *et al.* [12] noted a slow increase of the acidification of soil in the north-eastern zone independent of the applied fertilization with potassium, magnesium and sodium. However, in the objects with the potassium-sodium-magnesium fertilization the pH of soil was higher comparing to the objects without magnesium [12].

The application of the differentiated mineral NPK fertilization against the background of constant farm manure dose (25 t/ha) caused a slight decrease in the pH of soil and the increase in hydrolytic acidity comparing to the initial data.

The increase in the pH value in the objects without NPK but with the applied farm manure confirms the role of farm manure in the deacidification of soil.

Adamus *et al.* [1] and Nowosielski *et al.* [8] stress a definitely greater role of farmyard manure in the deacidification of soil as compared to the mineral fertilization. Rabikowska *et al.* [9] noted a favourable effect of fertilizing with farm manure on the pH of soil. The results of the research pertaining to the interaction between the organic fertilization and the mineral one in their effect on soil reaction are not univocal [5,13]. Kuszelewski *et al.* [5] noted that farm manure diminishes not only the acidifying effect of mineral fertilizers but also decreases the deacidifying effect of lime fertilizers. In the research of Urbanowski *et al.* [13] similar tendencies were noted. From the research of Turski *et al.* [11] carried out in the private farms in the central part of Obniżenie Podkarpackie it results that the organic fertilization and a sensible application of the mineral fertilizers combined with liming can neutralize the negative effects of the acidification of soils.

CONCLUSIONS

1. The application of the differentiated mineral fertilization against the background of the constant dose of farmyard manure caused slight acidification of brown soil formed from loess. The application of the constant dose of FYM without mineral NPK fertilization increased the values of pH_{KCl} of loess soil.

2. The application of constant fertilizing with magnesium (240 kg MgO/ha) during the 4-year long crop rotation against the background of differentiated doses of NPK fertilization caused quite distinct deacidification of soil. The greatest deacidification of soil was noted at the lack of the application: NPK, potassium nitrogen, and also at the increased dose of phosphorus.

3. Soil liming against the background of the differentiated doses of NPK and a constant magnesium dose, significantly decreased the deacidification of soil. The greatest deacidification of soil was noted at the lack of applying nitrogen, potassium and NPK fertilizers.

4. The hydrolytic acidity increased when the pH values of brown soil formed from loess decreased.

5. The increasing nitrogen fertilization against the background of phosphorus-potassium fertilization and potassium one against the background of the nitrogen-phosphorus fertilization and proportionally increasing NPK fertilization,

increased the acidification of brown soil formed from loess.

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WPŁYW RÓŻNYCH SYSTEMÓW NAWOŻENIA MINERALNEGO NA ZAKWASZENIE GLEBY BRUNATNOZIEMNEJ WYTWORZONEJ Z LESSU

Badania nad zakwaszeniem gleby brunatnoziemnej wytworzonej z lessu o składzie granulometrycznym pyłu ilastego przeprowadzono w latach 1982-85 oraz w latach 1986-89 na stałym polu nawozowym w regionie Podgórza Rzeszowskiego. W przeprowadzonym doświadczeniu w latach 1982-85 zastosowano zróżnicowane nawożenie mineralne NPK na tle stałego nawożenia obornikiem w dawce 25 t/ha. W latach 1986-89 prowadzono dwa doświadczenia, w których również stosowano zróżnicowane nawożenie mineralne NPK na tle stałego nawożenia magnezem oraz magnezem wraz z wapnowaniem. Doświadczenie prowadzono na kwaśnej glebie (1982-85) i bardzo kwaśnej glebie (1986-89). Zmianowanie roślin było podobne, różnice dotyczyły tylko gatunku rośliny pastewnej. W wyniku 4-letniej intensywnej uprawy roślin w zmianowaniu i zróżnicowanego nawożenia mineralnego na tle stałego stosowania pozostałych nawozów poprawił się odczyn gleby bardzo kwaśnej. Zwiększeniu wartości pH towarzyszył spadek kwasowości hydrolitycznej i odwrotnie.

S ł o w a k l u c z o w e: nawożenie NPK, zakwaszenie, gleby brunatnoziemne.