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ESTIMATION OF THE PERSISTENCE OF LIMING ACTION ON THE MOUNTAIN MEADOW

OCENA DŁUGOTRWAŁOŚCI DZIAŁANIA WAPNOWANIA NA ŁĄCE GÓRSKIEJ

Abstract: The study was conducted on a mountain meadow (altitude of 640 m) in the years 1999–2008. The investigations were located on the brown soil of the loamy sand granulometric composition. The soil was very acidic, the pH value amounted to 5.20 in H_2O and 4.28 in KCl. Two kinds of lime were used for liming in the autumn of 1998: calcium-magnesium carbonate in the amount of 1.5 Mg CaO and calcium oxide in the dose of 0.5 Mg CaO · ha^{-1}. Four variants were subjected to the study: control and 3 limed objects. Moreover, two kinds of fertilizers were also applied for two limed fields: phosphate-potassium – PK and phosphate--potassium-nitrogen – PKN. The meadow was mown twice a year. The evaluation of liming was carried out annually on the basis of the meadow yielding and soil pH after 3, 6 and 10 years from the treatment. Additionally, during the last year of the experiment, manganese, copper and cadmium content was determined in the soil from the control object and from the field where only liming was applied. The soil samples were collected from the layer of 0–15 cm. The investigations revealed that liming had no effect on the meadow yielding. On the other hand, it improved soil pH reaction, which increased by 0.4 – pH in H_2O and 0.4–0.7 – pH in KCl. The latter effect lasted for the following three years. The soil evaluation conducted after 10 years from the liming revealed significant decrease of soil pH. The lowest decrease was stated in the case of the object where only liming was applied, whereas the highest change was noticed for the object with full PKN fertilization. In the latter case the pH reached the value close to the level stated before liming. Liming had a beneficial influence as regards the manganese and cadmium concentration in the soil decreasing their levels by approximately 2.5 times. On the contrary, the copper level slightly increased under the action of liming.

Keywords: mountain meadow, liming, fertilization, yielding, soil pH

The meadow-pasture flora is quite tolerant as regards the soil pH reaction. Therefore, the efficiency of liming on the grasslands expressed as yielding is low [1–3]. The study of Gorlach and Curylo [1] revealed that the results of liming are visible in yielding only in the case of very acidic soils, when pH_{KCl} is below 4.0. The lack of liming effect on the plant yielding on the permanent grasslands can be explained by a high concentration of organic matter in the soil, which lowers the toxic action of aluminium and

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manganese. However, the forages produced on the acidic soils are characterized with weak quality and simultaneously are susceptible to the development of fungi as well as formation of nitrosamines. These facts fully justify the necessity of liming on the permanent grasslands.

The aim of this work was to estimate the effectiveness and persistence of liming effect on the mountain meadow.

Materials and methods

The study was conducted on a mountain meadow (altitude of 640 m) in the years 1999–2008. The investigations were located on the brown soil of the loamy sand granulometric composition. The soil was very acidic – the pH_{KCl} = 4.3. The experimental fields, except the control, were limed using 1.5 Mg CaO · ha^{-1} in the form of carbonate and 0.5 Mg CaO · ha^{-1} in the form of oxide. The dose of lime was calculated on the basis of the half of the hydrolytic acidity value of the soil (0.5 Hh). Four variants were subjected to the study: control and 3 limed objects. Table 1 and 2 present the scheme of the experiment. The following fertilization was applied in the meadow: 18 kg P – once in the spring, 66 kg K – in two equal doses – in the spring and for the second regrowth. The 100 kg · ha^{-1} dosage of nitrogen was divided: 60 % was used for the first and 40 % for the second regrowth. The meadow was mown twice a year. For the estimation of the soil pH as well as concentration of heavy metals the soil samples were collected from the layer of 0–15 cm. The soil reaction was determined after 3, 6 and 10 years and the content of heavy metals after 6 and 10 years from the liming. The dry matter content was evaluated by the drying method at 105 ^{o}C, crude protein content by the Kjeldahl method, and the content of heavy metals by ICP-AES (*inductively coupled plasma*) method.

Results

The productivity of the meadow was influenced mainly by the level of nitrogen, phosphorus and potassium fertilization (Table 1).

Table 1

Combined yield of dry matter and crude protein for 10 years [Mg · ha^{-1}]

Variant		Dry matter	Crude protein
Control		32.7	3.34
+ Ca	"0"	33.8	3.61
	$P_{18}K_{66}$	50.3	5.82
	$P_{18}K_{66}N_{100}$	64.8	7.51
LSD (p = 0.05)		6.92	—

The action of liming alone was not visible in the dry matter and crude protein yield during 10 years after it was applied. The fertilization with phosphorus and potassium

together affected 54 % higher dry matter yields and 74 % higher crude protein yield. On the other hand, the applied nitrogen dosage together with phosphate-potassium fertilization increase the yield of these components by 29 % as regards phosphate--potassium fertilization and 98 and 125 % in relation to the control.

The analyses of the soil conducted three years after liming revealed a distinct growth of the soil pH (Table 2). This pH reaction persisted on a similar level during the following three years and after the next four years it significantly decreased. The lowest pH decrease in respect to the value noticed 3 and 6 years earlier was stated for the object limed but not fertilized – 0.12 for pH in H_2O and 0.15 for pH in KCl. A higher difference was found for the object fertilized with phosphorus and potassium together, and the highest change – in the object where fertilization with three components ie nitrogen, phosphorus and potassium was applied. In the latter case the soil pH decreased to the level close to that stated 10 years earlier at the beginning of the experiment.

Table 2

Soil pH after 3th, 6th and 10th year of study

Variant		pH value					
		2001		2004		2008	
		H_2O	KCl	H_2O	KCl	H_2O	KCl
Control		5.20	4.28	5.20	4.25	5.19	4.26
+ Ca	"0"	5.60	4.90	5.90	4.85	5.78	4.70
	$P_{18}K_{66}$	5.60	5.00	5.60	4.96	5.50	4.52
	$P_{18}K_{66}N_{100}$	5.56	4.60	5.66	4.61	5.22	4.38

The effect of liming was also stated as regards the amount of some heavy metals assimilated in the soil (Fig. 1). The soil of the object limed, non-fertilized with nitrogen, phosphorus and potassium contained the same amount of copper and approximately 2.5

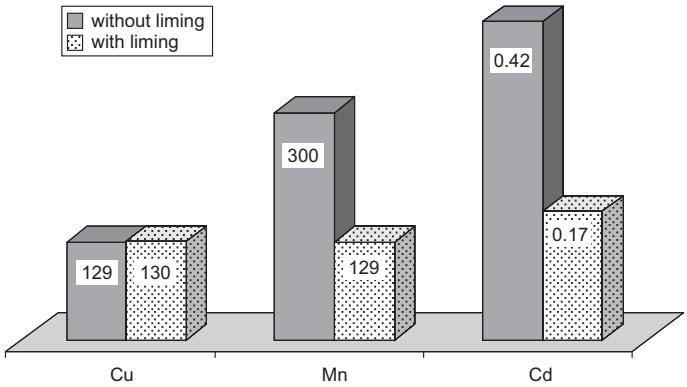

Fig. 1. The content of heavy metals as affected by the liming

times lower levels of manganese and cadmium when compared with the soil of the non-limed, control object. The concentrations of these elements were on a similar level when measured 6 years and 10 years after treatment [4].

Also other authors reported the lack of liming effect on the yielding of pastures and meadows [1, 2]. The stated lime action as a factor decreasing the soil acidity was close to the results obtained in the same region by Kopec [2]. The persistence of soil pH reaction on a similar level for 6 years after liming suggests that this phenomenon resulted from the slow movement of calcium deep to the soil profile [4]. 10 years after liming the greatest decrease of the soil pH in the object fertilized with phosphorus, nitrogen and potassium can be connected with the acidifying action of ammonium nitrate. The decreased level of assimilable cadmium and manganese, which show toxic action against soil, observed under the liming condition, should be recognized as a very positive phenomenon and consistent with the data found in literature [2, 5, 6]. On the contrary, liming did not affect the content of copper.

Conclusions

1. On the mountain meadow, the liming applied in a dose 2 Mg CaO · ha^{-1} did not influence the yielding but significantly affected and improved soil pH reaction, and decreased the amount of assimilable manganese and cadmium.

2. The persistence of liming effect was affected by the level of fertilization with other components. The application of nitrogen as ammonium saltpetre significantly shortened the effect of liming.

3. The effect of the lime dose in the amount of 2 Mg CaO · ha^{-1} on the chemical characteristics of the soil was significant even 10 years after treatment in the objects not fertilized with ammonium saltpetre, whereas the pH reaction of the soil from the object fertilized with ammonium saltpetre decreased at the same time to the level stated before liming.

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OCENA DŁUGOTRWAŁOŚCI DZIAŁANIA WAPNOWANIA NA ŁĄCE GÓRSKIEJ

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Abstrakt: Badania przeprowadzono na łące górskiej (640 m n.p.m.) w latach 1998–2008. Były one zlokalizowane na glebie brunatnej o składzie granulometrycznym piasku gliniastego. Była to gleba bardzo kwaśna, jej pH wynosiło w H_2O – 5,20, a w KCl – 4,28. Do wapnowania łąki użyto dwojakiego rodzaju wapna: węglanowo-magnezowego w ilości 1,5 Mg CaO i tlenkowego 0,5 Mg CaO · ha^{-1}. Zabieg ten wykonano jesienią 1998 r. W sumie badania obejmowały 4 warianty: kontrolę i 3 obiekty wapnowane. Ocenę wapnowania przeprowadzano corocznie na podstawie plonowania łąki i odczynu gleby po 3, 6 i 10. roku od zabiegu. W szóstym i ostatnim roku w glebie obiektów kontrolnego i z samym wapnowaniem dodatkowo oznaczono zawartość manganu, miedzi i kadmu. Próbki gleby do analizy pobierano z warstwy 0–15 cm. Wapnowanie nie wywarło żadnego wpływu na plonowanie łąki. Natomiast poprawiło odczyn gleb, zwiększając po 3 latach od wapnowania pH w H_2O o 0,4, a w KCl o 0,4–0,7 jednostki. Taki efekt tego zabiegu utrzymał się przez dalsze 3 lata. Natomiast ocena gleby wykonana po 10 latach od wapnowania wykazała znaczne zmniejszenie pH gleby. Najmniejsza była ona w obiekcie wyłącznie wapnowanym, a największa w obiekcie z pełnym nawożeniem (PKN). W tym ostatnim obiekcie pH gleby zbliżyło się do stanu sprzed wapnowania. Wapnowanie korzystnie wpłynęło na zawartość w glebie manganu i kadmu zmniejszając ich ilości około 2,5-krotnie. Natomiast wapnowanie nie miało wpływu na zawartość miedzi.

Słowa kluczowe: łąka górska, wapnowanie, nawożenie, plonowanie, pH gleby