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THE INFLUENCE OF DEFECATION LIME ON SOIL pH AND CONTENT OF AVAILABLE NUTRIENTS

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A b s t r a c t. In the paper the results of the influence of defecation lime brought into the soil in three ways on the pH level and on the content of certain available nutrients are discussed. The results show the positive effect of waste lime on the soil pH level. Liming also positively affected the content of available phosphorus in soil and to smaller extent the concentration of magnesium. It did not have any influence on the content of potassium.

K e y w o r d s: defecation lime, soil pH, available macronutrients

INTRODUCTION

The main reason which limits receiving high yields is a consequent and progressing soil acidification. The excessive acidity is observed not only in light, but also in medium-heavy and heavy soils. As the further result of the acidity increase, the content of many available nutrients decreases by washing out or forming insoluble compounds. The most important resource counteracting acidity is soil liming.

That is why the studies pertaining to the evaluation of the effect of defecation lime, as the most available liming medium around the sugar factory, introduced in different ways on the change of the soil pH and the content of some available nutrients in soil were undertaken.

MATERIALS AND METHODS

The studies were carried out on the basis of a 4-year field experiments on two soils: podzolic soil developed from light loamy sand (light soil) and brown soil developed from heavy loam (heavy soil). In model field experiments, performed according to split-plot method (split-plot in years) in four replications, two objects were taken into consideration:

A - control object - mineral fertilization $N_{70}P_{30}K_{55}$;

B - defecation lime + NPK.

Defecation lime was incorporated in three ways as follows:

I - applying the whole dose (6 t/ha) in the first year of the experiment;

II - applying the dose parted in 1/2 of the full dose during the first two years of the experiment;

III - using 1/3 of the full dose during each of the first three years of the experiment.

The fourth year, in which lime was not brought in, was the time to check its after-effect on soil.

Defecation lime and PK fertilizers and a part of nitrogen fertilizer were brought into the soil during the pre-sowing tillage. The rest of N fertilizer was applied as top dressing.

In Table 1 the chemical composition of defecation lime used in the experiments and its composition according to the literature data are displayed.

Winter rye grown as monoculture for 4 years of the study was chosen as a test plant.

Table 1. Chemical composition of defecation lime (% d.m.)

Defecation lime	D.m. (%)	N	P_2O_5	K_2O	Mg	CaO as $CaCO_3$	Organic matter
Lime used in experiment	74.4	0.47	0.35	0.25	0.35	40	7
Lime acc. to literature	50-80	0.40	1.20	0.10	1.00	45	3-10

Soil samples were collected every year after harvesting the plant.

In the soil the following were determined: pH in 1 mol/dm^3 KCL, available phosphorus and potassium with the Egner-Riehm's method and available magnesium by the Schatschabel's method. The results of these determinations were worked out statistically and they are given in Table 2.

RESULTS

Soil reaction

In the first year of the study, light soil from the control object had the acid reaction, while heavy soil had slightly acid reaction. During the following years of the experiment, light soil from this object was becoming acidified. In the third and the forth year this soil was considered to be very acid. The pH of heavy soil in the same objects during four years did not change much, which should be explained by good buffer properties of this soil.

Liming both of these soils made the pH increase even in the first year of the experiment. The increase in the pH of light soil, during the first two years, generally depended on the lime dose. In the third year, the amounts of lime brought in were the same on all limed objects, so the pH of soil from these objects was almost similar and significantly higher then in the control object. According to the average data for the ways of liming it was stated that higher doses used once and twice had the better influence on the pH of light soil.

The increase in heavy soil reaction has not been significantly differed by any of the ways of bringing lime in. In the fourth year it was stated that defecation lime had had the positive influence on pH of both soils on the level similar as in the third year.

Phosphorus

Light soil, in the first year of the experiment, had the low content of phosphorus no matter what the amount of lime was, and that year it did not significantly differ from the P content in the control object. A significant increase in the phosphorus content was observed in the second and the third year and soil of these objects have been classified into the medium group of soil phosphorus content. In the fourth year of the experiment it was found that liming had had the positive influence on the content of available phosphorus.

Heavy soil contained more phosphorus then light soil and it should be numbered among the soils of high P content. The lime used already in the first year of the experiment had the significant and positive effect on the growth of available P content. In the second and the third year we observe further increase in the content of this component. However, in the fourth year, a significant decrease in the phosphorus content not only in the limed objects but also in the control one was noted. This drop can be only explained by higher P uptake by the plants of rye. No significant influence of liming ways on the concentration of available phosphorus in both investigated soils have been observed.

Potassium

Light soil had the low content of potassium, while heavy soil - the medium one. Liming did not cause any considerable changes in the content of available potassium in light soil. While in heavy soil in the object with the highest dose of lime in the first year an increased content of this compound was recorded. However, in most limed objects in two soils the potassium level was similar or even lower then in

Table 2. pH_{KCl} and content of available forms of phosphorus and potassium (acc. to Egner-Riehm) and available magnesium (after Schatschabel), (mg/kg)

Fertilizer	Fertilization method*	Light soil 1**	2	3	4	Mean value (A)	Heavy soil 1	2	3	4	Mean value (A)
					pH						
NPK	Control	4.8	4.7	4.4	4.3	4.5	6.4	6.5	6.2	6.4	6.4
	I	5.5	5.2	5.2	5.0	5.2	7.0	6.8	7.0	6.8	6.9
Defecation lime	II	5.4	5.4	5.2	5.2	5.3	7.0	6.9	7.0	6.8	6.9
	III	5.1	5.1	5.3	5.0	5.1	6.8	7.0	6.9	6.7	6.8
Mean value (B)		5.2	5.1	5.0	4.9	5.0	6.8	6.8	6.8	6.7	6.7
LSD P = 0.05	(A)			0.1					0.1		
	(B)			0.1					0.1		
	(A) x (B)			0.2					0.3		
					Phosphorus						
NPK	Control	34	36	36	38	36	68	97	88	72	81
	I	38	46	47	47	45	82	102	112	78	94
Defecation lime	II	33	45	50	45	43	79	105	123	83	98
	III	37	42	43	44	42	86	104	126	76	98
Mean value (B)		36	42	44	44	42	79	102	112	77	93
LSD P = 0.05	(A)			8					7		
	(B)			8					7		
	(A) x (B)			12					10		
					Potassium						
NPK	Control	44	37	36	47	41	141	154	177	126	150
	I	46	44	44	43	44	155	140	163	141	150
Defecation lime	II	47	45	46	51	47	148	146	155	114	141
	III	45	46	38	35	41	131	146	167	142	147
Mean value (B)		46	43	41	44	43	144	147	166	131	147
LSD P = 0.05	(A)			n.s.					8		
	(B)			n.s.					8		
	(A) x (B)			n.s.					21		
					Magnesium						
NPK	Control	12	11	9	5	9.2	85	85	75	72	79.2
	I	13	12	8	8	10.2	109	104	75	80	92.0
Defecation lime	II	14	13	7	8	10.5	105	94	71	72	85.5
	III	12	11	8	5	9.0	107	101	76	74	89.5
Mean value (B)		12.7	11.5	8.0	6.5	9.8	101.5	96.0	74.2	74.5	86.6
LSD P = 0.05	(A)			0.8					0.8		
	(B)			0.8					0.8		
	(A) x (B)			2.0					2.0		

* Fertilization method (A) as explained in Materials and Methods.

** Years (B) of the study.

the control object. This can be explained by similar phenomenon as in the case of phosphorus, i.e. that plants grown in limed soil up taken more potassium.

Magnesium

The content of available magnesium in light soil, in the limed objects did not fluctuate much. Only in the case of applying the second way of liming there was a high increase in the content of magnesium in the first year of the experiment, as compared to the control object. No positive influence of liming on the concentration of this component in soil was stated in the third and the fourth year. There was also observed a continuous decrease in the magnesium content in all the objects as the years of the experiment were passing by, especially in the control object.

Heavy soil was the soil of medium magnesium content and liming really increased its content in this soil, especially during the first years of the experiment. A considerable decrease in the Mg content in all the objects was stated in the third year. and liming did not cause any marked changes in the Mg status. The positive effect of defecation lime application was only observed in the object with a full one-time dose.

DISCUSSION

As the result of liming used in the experiment, pH grew by 0.7 unit in light soil and 0.5 unit in heavy soil already in the first year. The increase in pH of heavy soil should be considered to be small, as compared to other data. Higher degree of deacidification was received in light soil, because this soil had much lower initial pH then heavy soil, which is similar to the results of other experiments [3,4]. Moreover, Schnee [9] reports that as soil pH increases and gets closer to the neutral reaction, more and more lime remains in soil in not very active carbonate form. That is why pH does not change much due to liming. Such a case occurred in the experiments performed in heavy soil.

Liming increased the content of available phosphorus by 7 mg P/kg in light soil and by 17 mg P/kg in heavy soil. Many authors [1-3] also accent positive influence of liming on the rise of available phosphorus content.

In the experiment, the growth of phosphorus amount was mainly observed in the second and the third year, after pH stabilized in the range 5.2-5.4 in light soil and around 7.0 in heavy soil. At the same time however, under the influence of liming the decrease in the content of available potassium occurred, especially in heavy soil. This phenomenon is common [5], and it can be explained by the fact that potassium is taken by plants in greater amounts then the rate of its transformation into the available forms. This is the reason, why the amounts of potassium in the limed objects are smaller than in the control ones. Moreover Rich [8] suggests that liming generally contributes potassium immobilization. The investigations allow us to assume that liming, in both experiments, have not had great influence on changing the content of available potassium in soils which is in accordance with the Terelak and Sadurski's conclusion [10].

The critical content of magnesium in soil is considered to be within the range 10-50 mg Mg/kg, depending on soil granulometric composition. The results of determining available magnesium in light soil point to the critical amount of this component. Adding the defecation lime into this soil, independent of the way of lime incorporation, did not improve the soil Mg content. Even in the third year we observed the decrease in the content of this component. Similar statements were given by other authors [6,7]. They stressed that the increase in the content of available magnesium in soils occurs, above all, after using magnesium lime. While the use of pure lime does not affect favourably the increase in the content of available forms of this component.

On the other hand, in heavy soil the significant increase in the content of magnesium in limed objects can be observed during the first and the second year of the experiment, while the decrease was observed in the third and the fourth year. That could have been caused by the Ca:Mg ratio in this soil and by higher uptake of magnesium by plants.

CONCLUSIONS

The results obtained on the basis of the four-year field experiments allow us to draw the following conclusions.

1. Defecation lime significantly affected the pH increase in light and heavy textured soils under study.

2. The tested waste lime significantly increased the content of available phosphorus, to less extent the content of magnesium, but it did not affect that of available potassium.

3. The three different ways of lime incorporation did not differ significantly as to their effect on the soil properties studied.

4. A significant after-effect of defecation lime was only found in case of pH, while it was weak as to the content of available phosphorus and magnesium.

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WPŁYW WAPNA DEFEKACYJNEGO NA pH GLEB ORAZ ZAWARTOŚĆ PRZYSWAJALNYCH SKŁADNIKÓW POKARMOWYCH

W pracy przedstawiono wyniki 4-letnich doświadczeń polowych, przeprowadzonych wg modelu split-plot, dotyczących wpływu wapna defekacyjnego z cukrowni, wnoszonego trzema sposobami na wysokość pH gleby lekkiej i ciężkiej oraz zawartość w nich przyswajalnych form P, K i Mg, na tle stałego nawożenia NPK.

Uzyskane wyniki wskazują na istotny dodatni wpływ testowanego wapna defekacyjnego na kształtowanie się odczynu gleby o składzie piasku słabogliniastego i gliny ciężkiej oraz na zawartość przyswajalnych form fosforu, w mniejszym zaś zakresie na zawartość magnezu i jeszcze mniejszym na zawartość przyswajalnego potasu. Sposoby wnoszenia wapna nie miały istotnego wpływu na kształtowanie się badanych cech gleby.

Słowa kluczowe: wapno defekacyjne, gleba piaszczysta i gliniasta, pH, przyswjalne formy makroskładników.