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FORMATION OF CHEMICAL PROPERTIES OF LIGHT SOIL FERTILIZED WITH MAGNESIUM SULPHATE AND DOLOMITE

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A b s t r a c t. The field experiment aimed at comparison of the effect of magnesium sulphate and dolomite on some properties of soil fertility. The trial was carried out on two experimental fields simultaneously in 4-field crop rotation and it included two crop rotations. Investigations were concerned on some elements of soil fertility: soil reaction, content of available components, changes of exchangeable cations in soil sorptive complex, sorption capacity and base saturation.

It was shown that dolomite was satisfactory fertilizer which improved content of available forms of magnesium in the soil. Besides that it was shown a positive effect of dolomite on soil acidity, soil sorption capacity and base saturation.

K e y w o r d s: light soil, magnesium sulphate, dolomite, soil reaction

INTRODUCTION

As it results from many research works, most Polish soils lack attainable forms of magnesium [1,4,5]. A number of experiments carried out with magnesium fertilizers indicate that fertilizing of acid soils with that element is necessary to increase plant yields [3-5]. Light, acid soils lack magnesium due to huge loss of that element through washing out inside soil profile [1,3,5,7]. Mercik [7] writes that an amount of magnesium in the soil layer of 50-75 cm is ten times higher than in arable layer.

Dolomites are a good source for manufacturing of magnesium fertilizers. Possibility of using dolomite fertilizers for agriculture has been suggested by many researchers [2,5,8].

The research conducted at the Institute of Agricultural Chemistry of the University of Agriculture and Technology in Olsztyn has been aimed at comparison of fertilizing effect between crude ground dolomite and magnesium sulphate. Another objective was to find doses and frequency of application of dolomite fertilizer into soil.

METHODS AND MATERIALS

An accurate field experiment has been carried out by the method of random blocks on leached brown soil formed from loose dumped sand. Before the experiment the soil pH in 1 molar potassium chloride had been 4.0 whereas content of available components in 100 g of the soil was as follows: P - 5.7 mg, K - 9.1 mg, Mg - 1.0 mg.

The experiment was conducted in the years 1982-1989 according to the diagram presented in Table 1. It was carried out on two fields simultaneously and the following plants were cultivated: oat, rye, maize, potato, spring barley, and winter triticale. Doses of N, P, K were calculated according to nutritive requirements of plants. During the first year of the research liming was carried in the amount of 53 dt CaO/ha with use of carbonate lime. Agricultural treatments were conducted according to the requirements of each cultivated plant.

Soil samples were taken after harvesting from the layer of 0-25 cm and put together in sets. The soil material was examined to determine: pH,

Table 1. Design of experiment

No.	Object	Form of Mg
1	NPK	No Mg
2	NPK+30 kg ha^{-1} MgO	Magnesium
3	NPK+60 kg ha^{-1} MgO	sulphate
4	NPK+90 kg ha^{-1} MgO	every year
5	NPK+30 kg ha^{-1} MgO	Dolomite
6	NPK+60 kg ha^{-1} MgO	every year
7	NPK+90 kg ha^{-1} MgO	
8	NPK+120 kg ha^{-1} MgO	Dolomite
9	NPK+240 kg ha^{-1} MgO	once
10	NPK+360 kg ha^{-1} MgO	for 4 years

Hh, available P, K, Mg, exchangeable cations (Ca^{2+}, Mg^{2+}, K^+, Na^+) by using conventional methods. Total exchangeable bases (S) has been calculated by summing content of exchangeable cations expressed in mmol(+)/100 g of soil. Cation exchange capacity T=S+Hh, and base saturation as V=(S:T)100 %.

The obtained results were statistically analysed to separate orthogonal contrasts. The complete set of contrasts is given in Table 2. The first contrast is to compare effect of NPK used along with magnesium to effect of NPK. The second contrast compares effect of magnesium sulphate to dolomite whereas the third contrast compares effect of the dolomite that is applied each year with the dolomite every 4 years. The contrasts from 4 through 9 compare doses of used magnesium fertilization. Statistical analysis conducted in such a way will help to answer questions put forward in the experiment treatment.

RESULTS

The years of the experiment (1982-1989) were characterized by lower precipitation. During the 8 years there was 4286 mm of rainfall that results in an average of 533.5 mm per year whereas an average from many years is 609.1 mm. Only in 1987 precipitation was higher and amounted to 623 mm. An average 24 h temperature during the research was 8.1 °C and was higher than an average from many years by 1.3 °C. Results of the research are given in Tables 3-6.

The lowest value of pH in 1 mmol KCl/dm^3 was obtained from objects fertilized only with NPK and from objects where magnesium sulphate had been applied (Table 3). Dolomite used every 4 years had the most favourable effect upon the soil reaction.

Content of the available forms of phosphorus varied within the range from 9.8 up to 10.2 mg P/100 g of soil and was not much differentiated due to the applied fertilizing. The used magnesium fertilizing lowered assimilability of potassium (Table 3) in relation to the object fertilized only with NPK.

Soil abundance with magnesium was closely related to a dose of applied component and increased along with greater dose. It was, at an average, 1.7 mg Mg/100 g of soil on the objects without magnesium fertilizing. The lowest magnesium fertilizing (30 kg MgO/ha per year of 120 kg MgO/ha every 4 years) increased content of available magnesium in soil by an average 49.4 % whereas the highest fertilizing (90 kg MgO/ha a year or 360 kg MgO/ha every 4 years)

Table 2. Complete set of orthogonal contrasts

Contrast	No Mg	Magnesium sulphate every year			Dolomite every year			Dolomite once for 4 years		
	0	30	60	90	30	60	90	30	60	90
	1	2	3	4	5	6	7	8	9	10
K_1	+9	-1	-1	-1	-1	-1	-1	-1	-1	-1
K_2		+2	+2	+2	-1	-1	-1	-1	-1	-1
K_3					+1	+1	+1	-1	-1	-1
K_4		+1	-1							
K_5			+1	-1						
K_6					+1	-1				
K_7						+1	-1			
K_8								+1	-1	
K_9									+1	-1

Table 3. Effect of form and frequency of applying magnesium on content of available and exchangeable elements in soils

No.	pH in 1M KCl	Available (mg/100 g)		Exchangeable cations (mmol(+)/100 g)				
		K	Mg	Hh	Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}
		No Mg						
1	5.6	9.7	1.7	2.35	3.49	0.21	0.34	0.17
				Magnesium sulphate every year				
2	5.8	9.0	2.3	2.13	3.69	0.27	0.32	0.17
3	5.6	8.9	3.2	2.21	3.25	0.35	0.32	0.16
4	5.8	8.9	3.9	2.06	3.51	0.42	0.32	0.16
				Dolomite every year				
5	5.8	8.9	2.8	2.04	3.79	0.33	0.33	0.17
6	5.9	9.1	2.8	1.92	3.67	0.36	0.32	0.17
7	5.9	8.4	3.7	2.02	3.64	0.39	0.30	0.16
				Dolomite once for 4 years				
8	6.0	8.5	2.5	1.96	4.22	0.31	0.31	0.17
9	6.0	8.5	3.0	1.97	3.87	0.34	0.31	0.18
10	6.1	9.1	4.0	1.88	4.03	0.44	0.33	0.19

Table 4. Division of Anova for available and exchangeable elements in the soil

Contrasts No.	F calculated							
	pH	K	Mg	Hh	Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}
K_1	9.79**	11.43**	31.50**	22.57**	n.s.	49.59**	n.s.	n.s.
K_2	22.15**	n.s.	n.s.	12.46**	14.06**	n.s.	n.s.	6.26*
K_3	9.07**	n.s.	n.s.	n.s.	8.19**	n.s.	n.s.	5.39*
K_4	n.s.	n.s.	7.60**	n.s.	4.56**	8.62**	n.s.	n.s.
K_5	n.s.	n.s.	4.22*	n.s.	n.s.	5.82**	n.s.	n.s.
K_6	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
K_7	n.s.	n.s.	5.61	n.s.	n.s.	n.s.	n.s.	n.s.
K_8	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
K_9	n.s.	n.s	9.21	n.s.	n.s.	11.46**	n.s.	n.s.

* 0.05; ** 0.01; n.s.

resulted in growth by 127.4 % in relation to the object fertilized only with NPK.

Division of variance analysis for the above mentioned factors of soil abundance is given in Table 4. Significant differences of pH values were obtained for orthogonal contrasts K_1, K_2, K_3 (values of F calculated higher than F tabulated). Contrast K_1 indicates significant difference in soil reaction between objects fertilized only with NPK and those fertilized with magnesium. Contrast K_2 indicates different impact of magnesium sulphate and dolomite upon pH of soil and K_3 points out more effective impact upon soil deacidification of dolomite used every 4 years as compared with dolomite applied each year.

Use of magnesium fertilizer had a highly significant effect upon content of available forms of that element in soil - contrast K_1. A form of fertilizer and its use frequency did not have significant effect upon content of this form of magnesium in soil: the contrasts K_2 and K_3 did not show that difference. However, a dose of magnesium was found highly significant for its assimilability in soil (contrasts K_4, K_5, K_7, K_9) in this way that each successive dose of Mg

Table 5. Effect of the form and frequency of applying magnesium fertilizes on S, T, V in the soil

Object	S	T	V (%)
	mmol(+)/100 g		
	No Mg		
1	4.00	6.31	63.5
	Magnesium sulphate every year		
2	4.30	6.34	67.4
3	4.09	6.30	64.8
4	4.41	6.43	68.2
	Dolomite every year		
5	4.61	6.54	70.0
6	4.52	6.41	70.3
7	4.52	6.45	69.6
	Dolomite once for 4 years		
8	4.84	6.76	70.7
9	4.71	6.66	70.4
10	4.96	6.85	72.2

in the form of $MgSO_4$ significantly increased the amount of available magnesium whereas dolomite used both each year and every 4 years showed that effect only for the highest doses.

Table 3 presents content of exchangeable cations (Ca^{2+}, Mg^{2+}, K^+, Na^+) and hydrolytic acidity. Hydrolytic acidity was the highest on the object without magnesium fertilizing. Use of dolomite both each year and every 4 years lowered value of hydrolytic acidity in relation to effect of magnesium sulphate.

The soil fertilized with dolomite contained more exchangeable cations of calcium but dolomite used every 4 years in integrated doses increased amount of Ca^{2+} in sorptive complex of soil in a more effective way. Content of Mg^{2+} and K^+ cations in the soil sorptive complex was similar to their described earlier content expressed in available forms. Amount of exchangeable sodium was not much differentiated (within the range of 0.16-0.19 mmol(+)/100 g of soil), however, dolomite fertilizing in integrated doses increased that form of sodium in soil.

Division of variance analysis of exchangeable cations content in soil and of hydrolytic acidity is presented in Table 4. Proved statistical differences with regard to hydrolytic acidity are: the contrast K_1 which indicates existence of difference between objects fertilized and not fertilized with magnesium as well as the contrast K_2 describing different effects of dolomite and magnesium sulphate.

Table 6. Division of Anova for S, T, V

Contrast	F calculated S	T	V
K_1	18.64**	n.s.	20.45
K_2	24.37**	9.68**	18.72**
K_3	8.14**	9.44**	n.s.
K_4	n.s.	n.s.	n.s.
K_5	n.s.	n.s.	4.01*
K_6	n.s.	n.s.	n.s.
K_7	n.s.	n.s.	n.s.
K_8	n.s.	n.s.	n.s.
K_9	n.s.	n.s.	n.s.

In comparison with magnesium sulphate a significant influence of dolomite fertilizing upon content of calcium in the exchangeable form (K_2) has been proved. Also better effect of integrated dolomite fertilizing was proved as compared to the each year one (contrast K_3). Significant difference in content of Ca^{2+} while increasing doses of magnesium from 30 up to 60 kg MgO/ha in the form of magnesium sulphate (contrast K_4) was noticed, too.

Significant difference in the content of exchangeable potassium was noticed for increasing of magnesium dose in the form of dolomite from 60 up to 90 kg MgO/ha - contrast K_7. Significant changes of exchangeable sodium content in the soil were noticed between fertilizing with magnesium sulphate and dolomite (K_2) as well as K_3 - use of dolomite every year as compared with the 4-year cycle.

Value of the sum of bases, capacity of sorptive complex and its base saturation are presented in Table 5. The sum of bases was the lowest for the object without magnesium fertilizing and amounted to 4 mmol(+)/100 g of soil. Fertilizing with magnesium increased the sum of bases and dolomite, especially in integrated doses, had more advantageous effect.

Capacity of the sorptive complex was within the range from 6.30 to 6.85 mmol(+)/100 g of soil and the relations were similar to those for the sum of exchangeable bases.

Base saturation of the sorptive complex reached the highest values for objects fertilized with dolomite every 4 years and was 72.2 %. Use of dolomite every year turned less effective and degree of saturation for these objects was lower. Magnesium sulphate increased base saturation of soil in relation to the object fertilized only with NPK, however that effect was weaker as compared to dolomite. The carried out analysis of variance of S, T and V proved the above mentioned interdependences (Table 6).

DISCUSSION

The investigations showed that content of available and exchangeably forms of magnesium were considerably increased under the effect of applying dolomite and magnesium sulphate. Results from other papers [2,3,6] confirmed a positive effect of magnesium fertilization on increasing available forms of this nutrient element in the arable layer.

Dolomite not only effected in increasing available forms of magnesium. Also, positive effects of applying dolomite to the soil were decreasing soil acidity, changing in soil sorptive complex saturation, and increasing of its capacity and base saturation.

Szukalski *et al.* [8] and Malińska *et al.* [6] noticed the same effect of positive impact of dolomite.

CONCLUSIONS

1. Fertilizing of light soil with magnesium enriched surface layer of soil with exchangeable and available forms of magnesium.

2. Dolomite lowered soil acidity especially when applied in integrated doses every 4 years.

3. Dolomite increased capacity of the soil sorptive complex and its base saturation, however, dolomite used every 4 years had more advantageous effect.

4. Crude ground dolomite turned to be a good magnesium fertilizer that significantly improves physical and chemical properties of soil. It may be used in integrated doses.

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KSZTAŁTOWANIE WŁAŚCIWOŚCI CHEMICZNYCH GLEBY NAWOŻONEJ SIARCZANEM MAGNEZU I DOLOMITEM

Celem porównania działania siarczanu magnezu i dolomitu na niektóre cechy żyzności gleby w 1982 roku założono doświadczenie polowe. Eksperyment prowadzono dwoma polami równocześnie w zmianowaniu cztero-członowym i obejmował on dwie rotacje uprawianych roślin. Badania objemowały takie elementy żyzności gleby jak: odczyn, zawartość składników przyswajalnych, zmiany kationów wymiennych w kompleksie sorpcyjnym oraz pojemność kompleksu sorpcyjnego i jego wysycenie zasadami.

Wykazano, że dolomit jest równorzędnym nawozem w poprawianiu zasobności gleby w dostępny magnez. Ponadto ujawniło się korzystne działanie dolomitu na kwasowość i pojemność sorpcyjną gleby oraz jej wysycenie zasadami.

S ł o w a k l u c z o w e: gleba lekka, siarczan magnezu, dolomit, odczyn gleby.