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THE pH CHANGES OF THE SOILS FORMED AS A RESULT OF RECLAMATION OF THE SAND-PITS

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A b s t r a c t. The alluvial soils in the Bóbr river valley, devastated by sand and gravel exploitation, were reclaimed for agricultural use. After reclamation treatment, the newly formed soil was very acid. Application of 5 Mg/ha lime elevated soil pH to 6-7, but during the following years, soil pH dropped again by about one half of the pH unit a year. Rapid drop in the pH level can result both from geological and soil-forming processes. Efficiency of mineral fertilizers applied in various combinations did not give the expected results and the yield of cultivated plants was not satisfactory. Mineral fertilization in various combinations did not result in the expected yield levels.

K e y w o r d s: pH, sand-pit reclamation, recultivated soils, agricultural reclamation.

INTRODUCTION

Filipek [5] divided the causes of soil acidification into natural such as: biological activity, direct and indirect influence of CO_2, oxidation processes and anthropogenic e.g. acidotrophic emissions, SO_2, NO_2, NH_3, CO_2, CO, mineral fertilization, mainly with nitrogen, solid and fluid wastes.

Motowicka-Terelak [12] reported that soil acidity depends also on texture and origin of the parent rocks. As a result of excessive soil acidification, processes like leaching of base elements, immobilisation of nutrient element, excessive accumulation of aluminium and manganese and mobilisation of heavy metals take place [5]. In the paper by Mercik and Sas [11] reasons for yield decrease under the influence of soil acidification are revised. According to the above mentioned authors, yield decrease could be the result of some toxic elements, suppressed uptake of such elements, as P and Mo, difficulties in Ca and Mg uptake and low sorption capacity of the soil.

Liming or application of organic fertilizers can minimize the negative effects of soil acidity [8,10,12,15].

The aim of the present work was to evaluate the reaction of raw, recultivated soils in the sand-pits area of the Bóbr Valley, and to estimate the influence of agricultural measures applied in the field experiment on the pH changes of the soil.

Characteristics of the experimental area

A field experiment was founded in the areas formerly used for gravel and sand exploitation near Nowogród Bobrzański on the river Bóbr in the Lubuskie voivodeship (Fig. 1). Before gravel and sand exploitation started, fertile overlay soil (light and medium texture alluvial soil) was stripped off and collected in piles at the edge of the exploitation field. After surface exploitation of the open cast, waste material with the diameter of 0.02-1.0 mm was lagged out. The plain surface was then dressed with the alluvial soil stored in piles. The depth of the formed soil material varied from 0.30 to 2.0 m. The levelled soil-surface was subjected to various measures of adapting the land to agricultural purposes. The field was ploughed, mineral fertilizers were applied and lupine as a soil conditioner was sown. After blooming, lupine was ploughed in and the field was taken over by a state-owned agricultural farm. The performed recultivation gave visible results. Ray yield was about 700 kg of grain/hectare.

Soil properties were described in the another paper [3]. The newly established soils were characterised by the following parameters:

- very acidic reaction (most samples with pH below 5),
- large variation in the content of silt and clay fractions (from 9 to 26%),
- low amounts of total and available for plants nutrients,
- the content of organic matter determined by the Tiurin's method was about 1.5%,
- the soil was very compacted, especially in the deeper layers.

METHODS

Field experiments were carried out in the period of 1986-90. The experiments were established following Zade's method of long plots. The experimental fields were 8 m wide and 80 m long.

In the first year the following plants were cultivated: winter rape - field No. I, winter ray - field No. II.

Mineral fertilization for winter rape was as follows:

1. Without fertilizer NPK + Ca

2. N - 100, P_2O_5 - 50, K_2O - 60 kg/ha + Ca
3. N - 200, P_2O_5 - 50, K_2O - 60 kg/ha + Ca
4. N - 300, P_2O_5 - 50, K_2O - 60 kg/ha + Ca
5. N - 140, P_2O_5 - 300, K_2O - 100 kg/ha + Ca
6. N - 280, P_2O_5 - 300, K_2O - 100 kg/ha + Ca
7. N - 420, P_2O_5 - 300, K_2O - 100 kg/ha + Ca
8. Doses as in farm Dobroszów: N 100, P_205 90, K_2O 100 kg/ha + Ca
9. N - 280, P_2O_5 - 300, K_2O - 100 kg/ha without Ca

Fertilization for winter ray was as follows:

1. Without fertilizer NPK + Ca
2. N - 100, P_2O_5 - 45, K_2O - 80 kg/ha + Ca
3. N - 200, P_2O_5 - 45, K_2O - 80 kg/ha + Ca
4. N - 300, P_2O_5 - 45, K_2O - 80 kg/ha + Ca
5. N - 100, P_2O_5 - 280, K_2O - 130 kg/ha + Ca
6. N - 200, P_2O_5 - 280, K_2O - 130 kg/ha + Ca
7. N - 300, P_2O_5 - 280, K_2O - 130 kg/ha + Ca
8. Doses as in farm Dobroszów: N - 100, P_2O_5 - 90, K_2O - 120 kg/ha + Ca
9. N - 200, P_2O_5 - 280, K_2O - 130 kg/ha without Ca.

Lime was used in the amount of 5 Mg/ha in the form of $CaCO_3$ before ploughing. Phosphorous and potassium fertilizers were used respectively as simple superphosphate and 50% potassium salt after ploughing. Nitrogen fertilization in the amount of 1/2 dose as ammonium nitrate was applied before sowing, and the rest, i.e. 1/4 in the early spring, then after 1 month the second 1/4 dose was spread out on the soil surface.

In the following years (1988-1990), ray in monoculture was planted. The field No. I was ploughed to the depth of 25 cm each year. Each year, the following fertilizers were used in the both fields:

1. Without fertilizer NPK
2. N - 100, P_2O_5 - 45, K_2O - 80 kg/ha
3. N - 200, P_2O_5 - 45, K_2O - 80 kg/ha
4. N - 300, P_2O_5 - 45, K_2O - 80 kg/ha
5. N - 100, P_2O_5 - 280, K_2O - 130 kg/ha
6. N - 200, P_2O_5 - 280, K_2O - 130 kg/ha
7. N - 300, P_2O_5 - 280, K_2O - 130 kg/ha
8. Doses as in farm Dobroszów: N - 100, P_2O_5 - 90, K_2O - 120 kg/ha
9. N - 200, P_2O_5 - 280, K_2O - 130 kg/ha

The same fertilizers as in the previous year were used, also the time of application was similar. Harvest was collected at the stage of full ripening with a combine harvester. The yields were presented elswhere [4]. Each year after harvest yield was measured potentiometrically.

RESULTS

Lime application in the amount of 5 Mg $CaCO_3$/ha considerably elevated soil pH (Tables 1 and 2). The soil samples taken after the harvest of 1987 from the field ploughed to the depth of 25 cm showed that pH in H_2O and 1 M KCl in the combinations 1-8 was, on the average, higher by 1.5 units than in the combination 9 (without lime).

In the samples from the field II, ploughed deeper up to 35 cm, the positive influence of liming was also noted, but the pH increase was slightly lower than in samples from the field I.

In the following years, pH level was decreasing from year to year. A decrease in the pH level of the field with shallow ploughing was more pronounced than in the soils from the field with deeper ploughing. With lower P and K fertilization levels, increasing doses of N fertilizer caused higher acidification of the soil. Nitrogen fertilizer influenced soil acidity in various ways. With lower P and K doses, an increase in the N amount caused a slight pH increase of the soil in the following experimental years. With higher P and K fertilization, however, an increase in the N doses caused a decrease of the soil pH. Differences between pH in H_2O in the years 1987 and 1990 in the combinations 6 and 7, were about 1.0 unit, and the difference between pH in 1 M KCl exceeded this value.

DISCUSSION

Soil reaction is the one of the most important factors influencing the yield of cultivated plants. In the fields formed as a consequence of sand pit recultivation in Dobroszów, beside physical factors, pH is very important for soil fertility. Lime applied in the amount of 5 Mg/ha in the first year of the experiment caused pH increase by around 1.5 unit, but in the following years pH was decreasing from year to year.

Fotyma and Zięba [6] stated that it is not possible to establish the optimum doses of liming for very acidic and acidic soils as they vary for different fields. The established doses of lime application vary considerably depending on the assessment method applied. Conclusions are drawn for natural ripped soils with stable

Table 1. pH changes in recultivated soil in Dobroszów. Ploughing depth 25 cm

No.	Fertilizer combination			pH								pH changes 1987-1990	
				1987		1988		1989		1990			
	N	P_2O_5	K_2O	H_2O	KCl	H_2O	KCl	H_2O	KCl	H_2O	KCl	H_2O	KCl
1	0	0	0	7.0	6.8	6.7	5.8	6.4	5.7	6.1	5.7	0.9	1.1
2	100	45	120	6.6	6.4	6.5	5.8	6.3	5.3	6.2	5.6	0.4	0.8
3	200	45	120	7.0	6.8	6.7	5.9	5.8	5.0	6.1	5.4	0.9	1.4
4	300	45	120	7.0	6.8	6.4	5.7	6.4	5.7	6.0	5.3	1.0	1.5
5	100	280	240	6.9	6.4	6.4	6.0	5.6	4.2	6.1	5.1	0.8	1.3
6	200	280	240	6.7	6.4	5.6	5.4	5.9	5.1	6.2	5.0	0.5	1.4
7	300	280	240	6.3	5.4	5.9	5.5	5.9	5.1	6.1	4.7	0.2	0.7
8	100	90	120	6.4	5.4	6.0	5.6	5.7	4.6	5.5	4.2	0.9	1.2
9	200	280	240	5.2	4.1	4.9	4.3	5.5	4.4	5.1	3.8	0.1	0.3

Table 2. pH changes in recultivated soil in Dobroszów. Ploughing depth 35 cm

No.	Fertilizer combination			pH								pH changes 1987-1990	
				1987		1988		1989		1990			
	N	P_2O_5	K_2O	H_2O	KCl	H_2O	KCl	H_2O	KCl	H_2O	KCl	H_2O	KCl
1	0	0	0	5.9	5.6	5.8	4.7	6.2	5.6	5.6	4.4	0.3	1.2
2	100	45	120	5.8	4.9	5.5	5.0	5.5	4.3	5.7	4.3	0.1	0.6
3	200	45	120	5.9	5.4	5.6	4.6	5.6	4.2	5.7	4.7	0.2	0.7
4	300	45	120	5.4	4.2	5.3	4.4	5.7	4.5	5.6	4.7	-0.2	-0.5
5	100	280	240	5.8	4.8	5.6	5.0	5.6	4.4	5.8	4.8	0.0	0.0
6	200	280	240	6.4	6.0	6.0	5.0	5.8	4.9	5.6	4.3	0.8	1.7
7	300	280	240	6.5	5.8	5.8	4.7	5.7	4.4	5.4	4.4	1.1	1.4
8	100	90	120	6.4	6.0	5.9	5.1	5.9	4.7	5.8	5.3	1.1	0.7
9	200	280	240	4.7	3.9	4.8	4.0	5.2	4.1	5.3	4.1	0.6	-0.2

characteristics. It is even more difficult to determine lime doses for raw, mechanically interrupted soils. In the case of recultivated soils in Dobroszów, the reason for the renewed acidification could be the H^+ cations, bound stronger by the sorption complex. This thesis is supported by the quite high hydrolytic acidity of 6.2 to 6.8 cmol/kg soil in the Ap layer. It is worth to mention, that in the Ap layer exchangeable aluminium was determined, but this aluminium form was not found in the deeper layers of the soil profiles. This phenomenon indicates that changes in the soil reaction could be the result of weathering.

The soil forming rocks in the Bóbr basin are in majority pure as far as their basic elements are concerned; they are acidic. To the south of Jelenia Góra in the Sudety Mountains, brown and podzolic soils are formed *in situ* from granite eluvium. To the north of this area, on the upland part of the Bóbr basin, the soil cover consists of various non-calciferous sedimentary rocks, solid and detached. Between this upland area and the Dalkowskie and Żarskie Hills, there is a large sandy plain of fluviglacial origin. Only the soils of the Dalkowskie and Żarskie Hills are reacher in nutrients (loess-like sediments and loams), but because of low soil erosion their influence on the alluvial soils of the Bóbr valley between Żagań and Nowogród Bobrzański is insignificant [7].

It is important to mention, that the Bóbr basin is very heavily afforested. This prevents water erosion. However, large amounts of humic acids are transported from the forest area. This organic acids exert large influence on the pH levels of river water and sediments, because they consists mainly of fulvic acids (the forests are mainly deciduous with the dominating species of Scotch pine).

Additionally, soil acidification could increase due to SO_2 and NO_x emission (acid rain) from the coal power plants in Germany [14].

Mineral fertilization could, of course, cause an increase of soil acidity, especially with nitrogen fertilizer. Such effect has been noted by many authors [1,2,8,10,11,15]. Also potassium fertilizers used on the soils without this element soil material, may increase soil acidity. K^+ ions enter the crystal net of the soil minerals.

Low microbial activity of the recultivated soils, caused by unfavourable water, physical and chemical properties could be a reason for soil acidification [3].

Taking into account the presented changes in the soil pH, liming will have to be repeated.

CONCLUSIONS

1. After the liming, the reaction of the recultivated soils in Dobroszów increased by about 1.5 pH units, but in the following years consecutive pH decrease was noted.

2. The reason for the fast pH lowering in the limed soil material is in the natural soil origin (acidic parent rocks, influence of forest complexes, especially the Bory Dolnośląskie forest) and anthropogenic acitivity (emission of acid gases, mistakes in recultivation).

3. To improve soil properties liming will have to be repeated.

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