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A PRELIMINARY ESTIMATE OF THE CURRENT STATE OF ACIDIFICATION OF THE MEADOW SOILS OF THE LUBLIN REGION (1990-1992)*

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A b s t r a c t. In the broad research project on the chemism of the meadow soil environment of the Lublin region a preliminary estimate of the current state of acidification of the meadow soils has been made. pH determination has been done in soil samples collected from 63 meadow locations of the region. The content of Ca, Fe and Mn in soil samples and vegetation of the meadows examined have also undergone determination.

The results of pH determination showed that about 20 % of the examined soil samples are very acid, 40 % - acid or slightly acid, 30 % - neutral, and 10 % - alkaline.

Very acid reaction concerned mainly light textured podzolic soils of the Podlasie region and the Lowland of Sandomierz as well as the majority of the post-bog soils and black earths. Slightly acid and neutral soils are those alluvial and soils developed on loess of the Lublin Upland. Generally, we can draw the conclusion that the soil reaction of meadow soils of the Lublin region is more dependent on the geographic location of the site rather than the local ecological conditions.

K e y w o r d s: acidification state, meadow soils

INTRODUCTION

On the contrary to the cultivated soils, the problems of acidity and liming of meadow soils are not so widely examined.

From the few accounts concerning this matter it is possible to conclude that it is mainly the result of the well-grounded feelling that natural grassland occurring on relatively young, not yet lessive deposits (alluvia, muds, peats) are characterized with neutral reaction or slightly acid, on the whole, which means they do not require liming [3,4,7,13].

Equally well-known is the fact that the meadow vegetation is more tolerant to acid reaction of soil environment therefore, attempts of using lime on grassland are here rarely undertaken.

In this situations not only the field researchers were surprised at more and often cases of unsuccessful management of the meadows of the recently meliorated formerly boggy grounds, which resulted from strong acidity of the soil environment.

Among others, such unsuccessful attempts made on the dried peat-land of the Lublin region [2,5], motivated the authors of this paper to pick up this subject, within the broad schedule of research on the chemism of the meadow soil environment of the region.

The main purpose of this paper was to make a preliminary estimate of the current state of the meadow soil acidification of the Lublin region, also in order to make a spatial analysis of the advances of the process as well

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as to establish the possible correlations betwen the reaction of soil and other constituents of the environment.

METHODS

pH determination (in H_2O and KCl) was conducted in soil samples collected from 63 diversified meadow sites, as far as ecology and utility reasons are concerned, dislocated relatively uniformly on the area of the region (Fig. 1). Moreover, for the sake of the current evaluation and potential susceptibility of the examined meadow habitats to the processes of acidification, the total content of Ca, Fe, and Mn, i.e., elements playing an essential role in the course of these processes, was determined in soil samples (0-20 cm) and vegetation (hay - the first cut).

GENERAL CHARACTERISTICS OF THE MEADOWS EXAMINED

The majority of 66 examined meadow habitats, i.e. 43 of them occurred within the

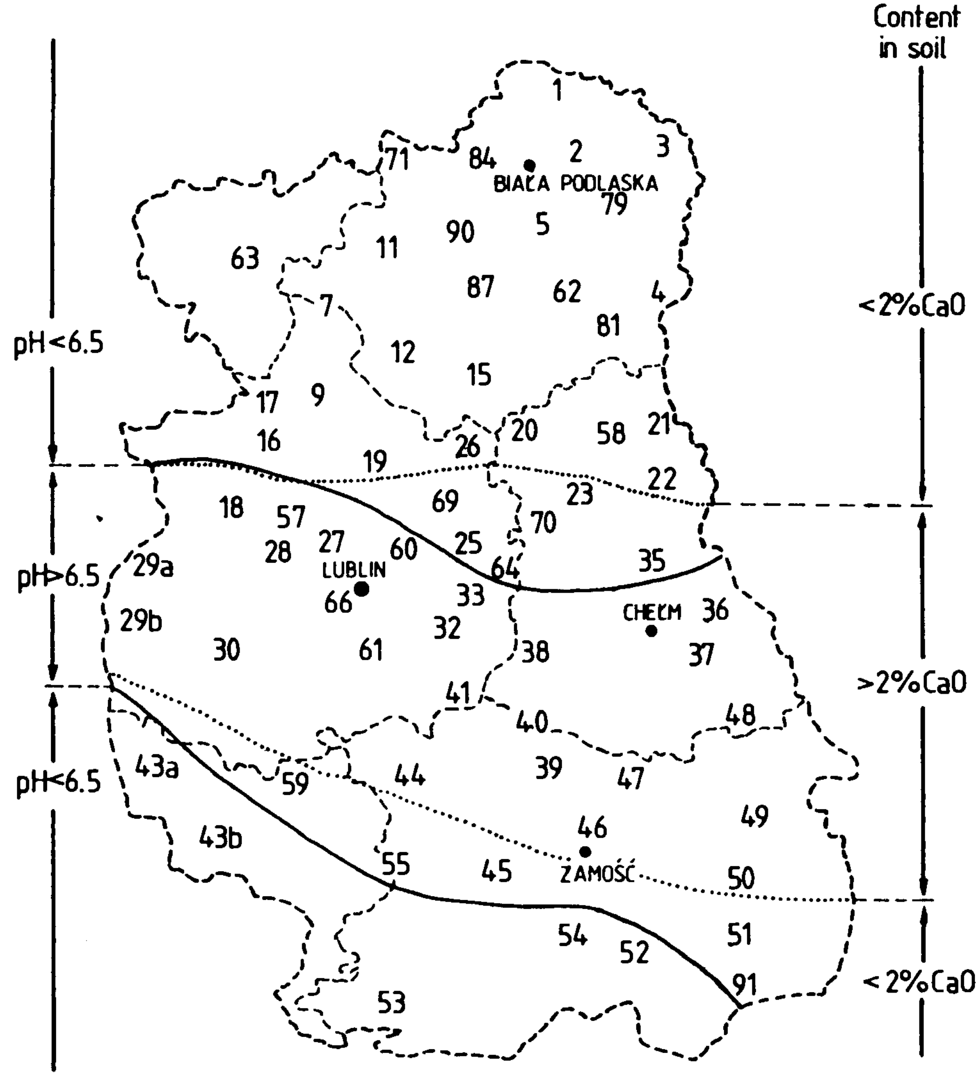

Fig. 1. Schematic map of the Middle-Eastern Region of Poland showing studied meadow objects.

river valleys. In 8 cases these are the meadows of the local cavings surrounded with arable fields (the Lublin Upland). Eight habitats are situated in the plains of Podlasie. The remaining sites are the peat-lands of post-lake origin and eroding loess slopes.

Taking into account the typology of meadows, the dominating forms are post-bog muck-peat soils, developed from mud and low peat (20 sites) and black earth of various granulometric composition. The next in line are alluvial soils (14 sites).

The other ones are podzolic soils developed from sands, silts of water origin and gley soils.

According to the Polish five class system of grassland evaluation, in 16 cases the examined soils can be classified as meadow soils - class II, in 17 cases - class III, in 21 - class IV. The remaining ones, classified as class V, are non-meliorated bog soils of peat-land.

Evaluating the pattern of water state on the sites examined we can assume that in 26 cases the sites were classified as dry, in 7 - as relatively or temporarily dry (periodically), in 6 - as optimum for meadows, in 16 - as moist, the remaining - as waterlogged.

RESULTS

Great diversity in organic matter content typical for the meadow soils, caused also in our research many problems, especially in analytical methods. Following the determination results obtained by burning in 600 °C we found that in the 66 examined samples, except for 8 cases of the soils definitely organic (>50 % o.m.) and 29 samples that can be classified as mineral soils (<10 % o.m.), there can be found the whole range of intermediate forms which included prevailingly strongly sedimentary soils of river valleys (peat and mud soils) and meadow black earths (mucky soils). In that case it was essential to decide in what solution should pH determination be applied (H_2O, KCl, $BaCl_2$). Although, pH determination in organic soils is usually conduced in the 0.5 mol $BaCl_2$ dm^{-3}, we decided to use the 1 mol KCl dm^{-3} for all the samples to have generally comparable results obtained [6].

Obtained results of pH presented on the map of the region (Fig. 1), show considerable diversification in relation to geographic location and indirectly to the contents and characteristics of parent rocks. Both the Northern areas (Podlasie) and the Southern sandy edges of the region (the Lowland of Sandomierz) can be clearly distinguished as regards the reaction, from the loess and rendzina areas of the Lublin Upland.

We found that about 26 % of the examined samples showed very acid reaction (pH 4.5), about 20 % - acid reaction (pH 4.6-5.5), 13 % - slightly acid (pH 5.6-6.5), 32 % - neutral (pH 6.6-7.2) and remaining 9 % showed alkaline reaction (pH>7.2).

Searching for interrelations between pH determination and the type of meadow soil it is possible to claim that very acid and acid habitats of 30 sites were related to podzolized mineral soils (lessivé soils), post-bog soils, (peat-muck soils) and certain black earths. Neutral and alkaline reactions concerned above all soils developed from loess and limestones as well as low peat soils rich in $CaCO_3$ occurring within the Lublin Upland.

The content of calcium which in cultivated soils has positive correlation with the reaction of the environment [11,13,14], in our examination of soils prevailingly rich in organic substance showed such correlation mainly in referrence to mineral soils (lessivé, brown, some alluvial soils) which are poor in calcium at considerable acidity and the lack of liming.

The dissimilarity of organic soils, distinctly visible in the co-ordinate systems (values obtained for peat soils, higher part of the correlation system) is connected with the apparent richnees of calcium in those soils, strongly bound with organic substance [2,3,5]. Consequently, vegetation from such meadows (hay) shows considerable deficiency of calcium (Table 1).

Similar correlation systems created for Fe and Mn showed the content of those elements both in soil and vegetation of the examined meadows to be positively correlated to the acidity level of the environment of the

Table 1. Some chemical properties and content of CaO, Fe_2O_3, and Mn in soils and plants of the Lublin region

No. of the site	Soil	pH in KCl	Organic matter	In soils			In plants		
			%	CaO %	Fe_2O_3 %	Mn mg kg^{-1}	CaO %	Fe_2O_3 mg kg^{-1}	Mn mg kg^{-1}
1	Gley soil	5.3	5.0	0.35	0.71	100	0.56	38	139
2	Black earth	4.4	14.7	0.21	0.44	134	0.35	18	161
3	Black earth	6.9	11.5	0.91	0.55	136	0.63	84	46
4	Soil lessive	4.0	4.1	0.28	0.46	165	0.56	147	208
5	Black earth	3.7	8.0	0.30	0.43	316	0.30	28	206
7	Alluvial soil	4.4	5.0	0.14	0.31	71	0.35	83	116
9	Black earth	5.5	3.4	0.42	0.55	178	0.70	84	86
11	Black earth	4.1	3.0	0.10	0.43	225	0.72	63	63
12	Black earth	7.2	5.5	1.12	0.47	394	0.42	28	32
15	Black earth	5.4	13.9	0.56	1.15	264	0.70	77	34
16	Black earth	6.4	11.4	0.91	0.48	315	0.63	182	35
17	Alluvial soil	4.2	8.4	0.44	0.83	232	0.77	84	247
18	Alluvial soil	7.1	8.8	5.95	0.81	335	1.12	103	32
19	Mineral-muck soil	5.1	18.7	0.91	0.60	107	0.49	77	70
20	Black earth	4.1	23.1	0.95	0.58	72	0.77	115	38
21	Peat-muck soil	4.4	59.7	1.96	0.61	47	0.70	62	75
22	Peat-muck soil	3.9	64.8	0.75	1.17	37	0.75	77	142
23	Peat-muck soil	5.2	95.6	4.48	0.34	21	0.77	84	59
25	Alluvial soil	5.9	6.3	0.42	1.02	492	0.49	82	196
26	Soil lessive	3.7	3.4	0.28	0.02	241	0.42	62	278
27	Alluvial soil	7.1	6.9	3.22	0.78	502	0.38	193	36
28	Peat-muck soil	6.9	66.5	4.55	1.05	398	1.22	136	108
29a	Alluvial soil	4.7	9.5	2.32	1.27	757	0.49	280	144
29b	Delluvial soil	5.3	12.3	1.05	0.70	688	0.42	158	96
30	Peat-muck soil	6.9	43.8	10.85	0.34	146	0.70	0.42	64
32	Alluvial soil	6.9	6.4	0.49	0.46	206	0.84	259	60
33	Black earth	7.1	12.3	4.48	0.87	633	0.63	42	79
35	Peat-muck soil	5.3	59.7	2.03	1.16	661	0.33	146	70
36	Black earth	7.6	10.7	2.66	0.50	184	0.72	110	53
37	Peat-muck soil	6.1	80.7	4.75	1.51	281	0.84	259	55
38	Alluvial soil	6.7	12.8	1.26	1.39	758	0.70	108	83
39	Alluvial soil	7.4	7.3	2.83	0.74	502	0.56	224	31
40	Alluvial soil	6.8	19.3	6.44	1.81	903	0.49	84	29
41	Alluvial soil	7.4	13.4	1.12	0.50	222	0.56	220	42
43a	Black earth	4.1	8.9	0.21	0.49	308	0.72	182	194
43b	Peat-muck soil	5.0	56.2	1.58	0.45	146	1.26	193	77
44	Mud-muck soil	6.8	22.7	3.50	1.83	433	0.35	84	140
45	Alluvial soil	6.6	11.8	0.70	0.80	108	0.63	62	125
46	Peat-muck soil	7.2	42.0	6.58	1.41	646	0.70	68	24
47	Mud soil	6.8	32.0	5.74	1.05	356	0.63	115	20
48	Peat muck soil	7.2	29.9	13.72	1.01	561	0.69	60	86
49	Mud soil	8.5	9.3	41.86	0.20	184	0.35	340	17
50	Peat-muck soil	5.9	35.6	2.24	3.20	389	0.91	315	55
51	Black earth	7.6	3.1	0.77	0.24	100	0.70	154	51
52	Peat-muck soil	4.0	37.5	1.12	0.64	171	0.63	136	105
54	Alluvial soil	4.0	21.6	0.42	0.63	183	0.42	185	170

Table 1. Continued

No. of the site	Soil	pH in KCl	Organic matter %	In soils CaO %	In soils Fe_2O_3 %	In soils Mn mg kg^{-1}	In plants CaO %	In plants Fe_2O_3 mg kg^{-1}	In plants Mn mg kg^{-1}
55	Alluvial soil	7.0	4.2	0.98	0.41	54	0.77	84	60
56	Alluvial soil	7.0	10.5	3.29	1.48	860	0.96	290	58
57	Delluvial soil	7.3	22.0	27.44	0.53	634	1.19	588	40
58	Black earth	4.8	15.4	2.35	0.74	73	0.28	62	103
59	Alluvial soil	7.1	8.7	1.12	0.58	411	0.71	290	45
60	Alluvial soil	7.1	5.8	1.40	0.43	298	0.63	42	27
61	Alluvial soil	6.7	15.1	1.10	0.92	654	0.70	40	38
62	Alluvial soil	6.7	11.4	1.47	0.84	766	0.91	203	106
63	Peat-muck soil	4.9	58.6	1.52	0.83	341	0.35	42	66
64	Mineral-muck soil	4.5	20.5	1.33	0.76	112	1.12	127	125
65	Peat-muck soil	7.0	36.2	9.69	0.97	847	0.63	259	67
66	Brown soil	6.7	4.8	0.35	0.75	331	0.91	42	166
71	Soil lessive	3.7	1.1	0.12	0.46	232	0.42	28	274
79	Soil lessive	4.7	0.9	2.85	0.38	407	0.56	207	161
81	Soil lessive	4.0	4.5	0.14	0.33	45	0.43	42	227
82	Alluvial soil	5.0	2.7	2.70	0.40	48	0.42	18	67
84	Black earth	4.2	6.2	0.49	0.30	152	0.56	83	46
87	Alluvial soil	6.3	6.7	0.51	0.92	227	0.40	84	104
90	Black earth	4.2	6.2	1.43	0.29	136	0.41	108	47

examined meadows. The higher content of both Fe and Mn was usually with the neutral reaction of soil and the higher amount of compounds of calcium (it concerned mainly alluvial soils and some black earths). At the greater level of soil acidity (lessivé, acid peat soils), however, with the increased mobility of alkaline compounds (Ca) as well as the discussed Fe and Mn, the content of those elements definitely decreases. This relationship accused as a distinctive deficiency of Fe and Mn in the gathered hay (Table 1).

DISCUSSION

Taking into account data on the national scale from the 1980 [13], when 55 % of meadow soils showed acid or slightly acid reaction, the situation in the Lublin region 10 years later presents itself a little more favourably (only 46 % of meadow soils show acidity). Still it is not consoling to realize that at that time the percentage of meadow soils in Poland with very acid reaction (15 %) was much lower than it is found at present in our region (26 %).

Not going too deep into interpretation this fact, where the essential role is played by the soil specificity of the region [2,6], we can assume the thesis that we face a strong influence of increasing anthropogenic factors on the course and intensity of acidification processes affecting the soil environment [2,13].

Being aware of the country's economic situation and the traditional altitude of Polish farmers towards fertilizing grasslands, it is dificult to agree with thesis accepted for cultivated soils which claims that one of major reasons of meadow acidification is excessive nitrogen fertilization [1,15]. More convincing though more poorly examined, is the role of the progressive process of the calcium loss in the meadow soil environment [2,6,13]. This process, at the lack of meadow fertilization with calcium, together with acidification of soil creates the situation of the need for calcium for meadow vegetation. We may even risk the claim that in the problem of acidity and liming of meadow soils, this latter question is the most vital element.

To bring this discussion to an end we should answer the basic question, if the current state of meadow soil acidification of the Lublin region requires preventive actions.

From the survey of the literature we can conclude that in this matter there is no uniform approach. While in some papers [9] authors state that liming meadow soils is necessary only at pH 4.5 (where only 25 % of meadow soils of the region would require liming), other researchers, including foreign authors [8,10,12], are of the opinion that meadow liming may be necessary already at pH 5.5. The latter also claim that optimum reaction for meadows may differ and, depending on the granulometric composition of soil and the content of organic substance, may fluctuate from pH 5.0, for peat soils to pH 6.0 and even 6.5 for heavier mineral soils [10,12]. Taking into consideration such extremal numbers, almost half of the meadow area of the region would require liming.

Considering the analysis result regarding the content of calcium in the examined hay, the improvement of providing a meadow area with calcium seems justified.

CONCLUSIONS

1. The reaction of the examined meadow soils fluctuates in broad range (pH in KCl 3.7-7.4) depending on the site location and the mother rock of soil.

2. Almost half the grassland area of the region revealed acid or very acid soil reaction (pH 5.5).

3. The higher soil acidity concerns most often the podsolized light textured soils of Podlasie and the Lowland of Sandomierz, and most of the post-bog soils. Slightly acid neutral reaction there are alluvial and soils developed from loess of the Lublin Upland.

4. The content of Ca, Fe and Mn in the soils examined showed distinct positive dependence on their reaction.

5. At stronger acidification of soil, the content of Ca, Fe and Mn in the collected hay reveals the shortage of these elements in the environment of the examined meadows.

6. In reference to the accepted criteria of division of pH, 25-50 % of the grassland area of the region shows the need to be fertilized with calcium.

7. It can be accepted that the reaction of the meadow soils of the Lublin region is more dependent on the geographic location of site than on the local ecological conditions.

8. Relatively small number of the examined sites does not allow us to draw further-reaching conclusions and generalizations. We expect to be able to obtain a wider estimate of the situation after the termination of the second stage of research after we have acquired a greater number of data from about 200 habitats.

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WSTĘPNA OCENA AKTUALNEGO STANU ZAKWASZENIA GLEB ŁĄKOWYCH REGIONU LUBELSKIEGO

W szerokim programie badań nad chemizmem środowiska gleb Regionu Lubelskiego dokonano również wstępnej oceny aktualnego stanu zakwaszenia tych gleb. Oznaczenia pH wykonano w próbkach gleby pobranych z 63 obiektów łąkowych Regionu. Oznaczono również zawartość Ca, Fe i Mn w próbkach gleby i roślinności badanych łąk.

Uzyskane wyniki oznaczeń pH wykazały, że około 20 % badanych prób to gleby bardzo kwaśne, 40 % - kwaśne i słabokwaśne, 30 % - obojętne i 10 % - zasadowe. Odczyn bardzo kwaśny dotyczył głównie zbielicowanych gleb lekkich terenów Podlasia i Niziny Sandomierskiej oraz większości gleb pobagiennych. Natomiast słabokwaśne i obojętne to aluwialne i nalessowe gleby Wyżyny Lubelskiej. Ogólnie można wnioskować, że odczyn gleb łąkowych Regionu Lubelskiego jest bardziej uzależniony od podłoża geograficznego obiektu, niż od lokalnych warunków ekologicznych.

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