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FEASIBILITY OF HUMIDOL APPLICATION FOR IMPROVING FERTILITY OF SANDY SOILS IN THE LEGNICA-GŁOGÓW COPPER DISTRICT (LGOM)

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A b s t r a c t. Effect of organic (with Humidol Standard) and mineral (with NPK) fertilisation on some physico-chemical and chemical properties of sandy soils in the LGOM region were studied. The experiment was founded with two factors and a sub-block method. Humidol Standard was introduced once, and mineral fertilisation each year. The studies showed that fertilisation with Humidol Standards increased the amount of organic matter, improved fraction composition of humic compounds and physico-chemical properties of sandy soils. Fertilisation with Humidol Standard combined with NPK can be a safe agrotechnical treatment that improves soil fertility in a short period of time in the region of LGOM.

K e y w o r d s: mineral-organic fertilisation, mineral fertilisation, sandy soils, soil fertility, Humidol Standard.

INTRODUCTION

The amount and quality of humic compounds plays an important role in soil fertility [1,5,15,23]. Favourable influence of humic compounds is especially visible in the sandy soils with poor content of mineral colloids that are often of acidic reaction. Organic fertilisation together with reaction adjustment are of primary importance in improving fertility and yield of light soils [9]. At present a few unconventional organic fertilisers produced on the basis of peat, brown coal, industrial and municipal waste and sewage sludge are used for soil fertilisation. They contain considerable amounts of organic matter with properties that are close to specific humic compounds. Their usage for fertilisation enables a relatively stable growth of the soil humus content [6,12,16,17]. Specific features of the organic fertilisers produced from peat and brown coal make them useful for agromelioration and recultivation of the soils [12,18].

The aim of the present study was to recognise effects of organic-mineral fertilisers (Humidol Standard) and mineral fertilisers (NPK) on some chemical and physico-chemical properties of sandy soils located in the Legnica-Głogów Copper District.

MATERIALS AND METHODS

The soil material for laboratory experiments was collected in the experimental fields. The experiment was founded on the podzolic soil originating from weak loamy sand deposited at the medium depths on loose sand. It was situated in the Rudna commune, 2.5 km to the east from the pond for post-flotation deposits Żelazny Most.

In the two-factor experiment, founded according to the method of sub-blocks with 4 repetitions, the following combinations of fertilisers were applied: organic-mineral with Humidol Standard (factor A), mineral with NPK (factor B) according to the experimental scheme given below:

A_0 B_0	A_0 B_1	A_0 B_2	A_0 B_1	A_0 B_2	A_0 B_0	A_0 B_2	A_0 B_0	A_0 B_1	A_0 B_2	A_0 B_1	A_0 B_0
A_1 B_0	A_1 B_1	A_1 B_2	A_1 B_1	A_1 B_2	A_1 B_0	A_1 B_2	A_1 B_0	A_1 B_1	A_1 B_2	A_1 B_1	A_1 B_0

Explanations:

Ao- 0 dt/ha of Humidol Standard

A_1 - 300 kg dt/ha of Humidol Standard

Bo - 0 NPK (0 kg/ha N, 0 kg/ha P, 0 kg/ha K)

B_1 - NPK (100 kg/ha N, 100 kg/ha P, 150 kg/ha K)

B_2 - N2PK (100 kg/ha N, 200 kg/ha P, 150 kg/ha K).

Humidol Standard was introduced once when this experiment was being founded, whereas mineral fertilisation with NPK was applied each year on the agrotechnical dates suitable for potato growing [20]. Soil samples for laboratory analysis were collected from the depth of 0-20 cm in four repetitions, after picking potatoes grown in a two-year monoculture. The following parameters were determined: pH in 1 M KCl - by the potentiometric method, exchangeable cations (Ca, Mg, K, and Na) by the Pullmann's method, Hh by the Kappen's method, oxidable organic C by the Schachtschabel's method, total content ($HClO_4$ soluble forms) of Pb, Zn, Cu, Ni, Mn, and Fe and their available forms (soluble in 1 M HCl). Results of analyses were statistically worked out, and significance of differences was determined between the average values with the t-Student's tests.

Humidol Standard is an organic-mineral fertiliser produced by Przedsiębiorstwo ECO-21 C Sp. z o.o. (ECO-21 C, Co. Ltd.) in Rudna from ground brown coal, calcium meal and dolomite meal. It contains about 28% of organic C (oxidable) and 14% of CaO, 3% of MgO, macro- and micro-elements, and its reaction in neutral (pH KCl - 6.75).

RESULTS

Results of the present studies are given in Tables 1-5. They confirm favourable influence of the applied fertilising combinations on the specific soil parameters. One-time application of Humidol Standard to sandy soils (Table 1) significantly raised the content of organic C (oxidable). In the fertilising combinations of the A1sub-block (fertilisation with Humidol Standard) the content of C-humin acids increased markedly at the same time. The two-year fertilisation with mineral fertilisers (NPK) did not increase the total C content or the content of C-humic acids in the soils of the individual sub-blocks.

Mineral fertilisation of sandy soils increased the rate of organic matter transformation. It was expressed as a significantly higher degree of humification in the fertilised soils as compared to the control combination (objects A_o and B_o). The applied fertilisation variants caused a series of changes in the physical and chemical soil properties (Table 2). In the objects fertilised with Humidol Standard the pH values increased considerably when compared to the objects fertilised with NPK, and the Ap horizons of these soils showed a slightly acid reaction.

In the A sub-block, only the soil of the control combination (Ao Bo) showed a slightly acid reaction, and in the remaining soils of this sub-block, mineral fertilisation resulted in a decreasing tendency of the pH values, which allowed to classify these soils as acid.

Deep reaching changes under the influence of Humidol Standard and NPK fertilisation were also manifested in the sorption complex (Tables 2 and 3). The basic cations of the sorption complex in the analysed soils were calcium and magnesium. Their amounts increased significantly under the influence of Humidol fertilisation. Mineral fertilisation did not influence the amount of these cations in such a significant way in the boundaries of the A sub-block combinations. In the A_1 sub-block fertilised with Humidol, its co-operation with N2PK (combinations A_1B_2) resulted in a significant decrease of exchangeable calcium level in the sorption complex.

The content of exchangeable potassium in the analysed soils was low and rarely exceeded 0.2 cmol (+)/kg. Its amount in the sorption complex of the studied soils was mainly influenced by the mineral fertilisation. Similarly, the objects

T a b l e 1. Some physicochemical properties of organic matter in treated soils

Fertilisation	Corg. (oxidable) mg/100 g soil			Ckh mg/100 g soil			E4/E6 humic acids			Humification degree of organic matter (%)		
	A_o	A_1	$\overline{X}$	A_o	A_1	$\overline{X}$	A_o	A_1	$\overline{X}$	A_o	A_1	$\overline{X}$
Bo	4190	6096	5143	1064	2024	1544	4.8	5.4	5.1	49.7	54.4	51.9
B_1	4328	5624	4976	1147	1721	1434	4.6	5.3	5.0	54.2	53.9	54.1
B_2	4436	5867	5158	1198	2016	1607	4.8	5.4	5.1	55.3	56.6	56.0
$\overline{X}$	4318	5867	-	1136	1920	-	4.7	5.4	-	53.0	55.0	-
LSD α=0.05	365		543	290		428	0.3		0.4	1.9		3.1
LSD α=0.05 AxB		485			382			0.4			2.8	
Humidol Standard		282280			172269			6.0			59.5	

T a b l e 2. Contents of base exchangeable cations in soil sorption complex

Fertilisation	Ca			Mg			K			Na		
	cmol(+)/kg											
	A_o	A_1	$\overline{X}$	A_o	A_1	$\overline{X}$	A_o	A_1	$\overline{X}$	A_o	A_1	$\overline{X}$
Bo	1.19	2.35	1.77	0.27	0.50	0.38	0.12	0.16	0.14	0.12	0.10	0.11
B_1	1.14	2.07	1.60	0.25	0.46	0.35	0.22	0.26	0.24	0.15	0.09	0.12
B_2	1.31	1.83	1.57	0.32	0.42	0.37	0.20	0.19	0.20	0.11	0.08	0.09
$\overline{X}$	1.21	2.08	-	0.28	0.46	-	0.18	0.21	-	0.12	0.09	-
LSD α=0.05	0.35		0.52	0.10		0.14	0.06		0.08	0.02		0.02
LSD α=0.05 AxB		0.46			0.13			0.07			0.02	
Humidol Standard		57.80			9.32			0.18			0.20	

T a b l e 3. Physicochemical properties of treated soils

Fertilisation	pH in 1 M KCl			Hh			S			T			V		
				cmol(+)/kg									%		
	A_o	A_1	$\overline{X}$	A_o	A_1	$\overline{X}$	A_o	A_1	$\overline{X}$	A_o	A_1	$\overline{X}$	Ao	A_1	$\overline{X}$
Bo	5.62	6.48	6.05	1.31	1.32	1.31	1.70	3.01	2.36	3.01	4.33	3.67	56.2	69.6	62.9
B_1	5.25	6.08	5.66	1.53	1.51	1.52	1.75	2.88	2.31	3.28	4.38	3.83	53.1	64.6	58.9
B_2	5.30	6.48	5.89	1.80	1.48	1.64	1.92	2.51	2.22	3.71	3.99	3.85	51.7	62.9	57.4
$\overline{X}$	5.39	6.34	-	1.55	1.43	-	1.79	2.8	-	3.33	4.23	-	53.7	65.7	-
LSD α=0.05	0.31		0.51	0.22		0.33	0.38		0.57	0.34		0.50	5.9		8.8
LSD α=0.05 AxB	0.46			0.30			0.51			0.45			7.9		
Humidol Standard	6.75			3.69			67.50			71.19			94.8		

T a b l e 4. Content of available forfms of macro-elements

Fertilisation	P mg/kg			K mg/kg			Mg mg/kg		
	A_0	A_1	$\overline{X}$	A_0	A1	$\overline{X}$	Ao	A1	$\overline{X}$
B_0	38	51	44	38	50	44	20	40	30
B_1	46	54	50	74	59	66	18	35	26
B_2	53	70	61	77	91	84	27	36	31
$\overline{X}$	43	58	-	63	66	-	22	37	-
LSD α=0.05	5		7	24		36	8		12
LSD α=0.05 AxB		7			31			11	
Humidol Standard		13			83			229	

fertilised with Humidol as a rule showed a lower amount of exchangeable sodium in the sorption complex.

The way the content of individual basic cation content was formed influenced their total amount and degree of saturation of the sorption complex. These parameters increased significantly in the soils of the A_1 sub-block that was fertilised with Humidol Standard. The influence of the fertilisation with Humidol combined with NPK on the content of S and V was not seen. In the A_0B_2 combination there was only a significant increase of the sorption capacity caused mainly by high hydrolytic acidity.

Fertilisation treatments played an important role in the formation of the available macro- and micro-elements. The applied fertilisation variants (Table 4) influenced an increase in the content of available K and P forms, what is more, the interaction of mineral fertilisation and Humidol in the A_1B_2 combination (N_2PK with 300 dt/ha of Humidol) proved to be important. Mineral fertilisation did not change the content of available Mg in any significant way, but its significantly higher levels were found only in the soils of the A_1 sub-block fertilised with Humidol Standard.

Total content of Pb, Cu, Zn, Ni, Fe, and Mn (Table 5) in all the study objects were low and with little variation. Despite their significantly higher content (except Cu) in the A_1 sub-block, all the accumulation levels in the studied soil can be classified as unpolluted with heavy metals. The amount of available forms of these metals in the soils are considerable. On the basis of the threshold values, the soils can be classified as the soils rich in Cu and medium rich in Zn, Fe, and Mn. Also the content of lead soluble in 1 M HCl is considerably high and ranged from 7.1 to 10.4 mg/kg.

T a b l e 5. Contents of total and available forms of selected microelements (mg/kg)

Fertilisation	Pb			Cu			Zn			Ni			Fe			Mn		
	A_0	A_1	$\overline{X}$	A_0	A_1	$\overline{X}$	A_0	A_1	$\overline{X}$	A_0	A_1	$\overline{X}$	A_0	A_1	$\overline{X}$	A_0	A_1	$\overline{X}$
Total forms soluble in $HClO_4$																		
B_0	13.4	14.4	13.9	7.1	7.2	7.2	15.9	17.8	16.8	4.3	6.4	5.3	2361	3449	2905	111	193	152
B_1	13.5	14.6	14.1	7.0	7.2	7.1	15.1	16.8	15.9	5.7	7.1	6.4	2345	3161	2753	113	199	156
B_2	13.3	16.5	14.9	7.2	6.9	7.1	17.0	18.7	17.9	6.7	7.8	7.2	2705	3405	3054	112	200	156
$\overline{X}$	13.4	15.2	-	7.1	7.1	-	16.0	17.8	-	5.6	7.1	-	2470	3339	-	112	197	-
LSD α=0.05	0.8		1.1	0.3		0.4	1.8		2.7	0.4		0.6	579		861	52		77
LSD α=0.05 AxB		1.0			0.4			2.4			0.6			770			69	
Humidol Standard		65.5			9.5			74.5			24.5			5298			315	
Available forms soluble in 1 M KCl																		
B_0	7.1	10.4	8.8	3.8	4.3	4.0	1.8	3.1	2.4	0.3	0.5	0.4	497	768	632	66	120	93
B_1	7.2	9.4	8.3	3.8	4.0	3.9	1.9	3.0	2.5	0.5	0.5	0.5	457	673	563	66	103	83
B_2	7.9	9.8	8.9	3.9	3.8	3.8	2.2	3.4	2.8	0.5	0.4	0.5	497	722	610	74	104	69
$\overline{X}$	7.4	9.9	-	3.8	4.0	-	2.0	3.2	-	0.4	0.4	-	483	721	-	67	109	-
LSD α=0.05	0.7		1.1	0.2		0.3	0.7		1.1	0.1		0.1	91		135	22		33
LSD α=0.05 AxB		1.0			0.3			1.0			0.1			121			29	
Humidol Standard		22.6			1.1			15.6			1.6			1777			163	

Fertilisation with Humidol Standard significantly increased the amounts of soluble Pb, Zn, Fe, and Mn forms. No significant influence of mineral fertilisation on the differentiation in the amounts of the soluble forms of the studied micro-elements was confirmed.

DISCUSSION

One of the basic conditions for maintaining very light sandy soils as arable land is improving their fertility and yielding potential. A significant improvement of the utilitarian properties of light soils in the light of data quoted by Gonet [9] can be made using agrotechnical methods, and among others, fertilisation with organic and mineral-organic fertilisers and control of their reaction. In the soils fertilised with Humidol Standard the content of organic C increased considerably. Even though the applied Humidol Standard dose was only 300 dt/ha of Humidol Standard in the second experimental year, humus content of the sub-block treated with Humidol was about 30% higher, and the content of humic acids increased by about 70% as compared to the soils in which no mineral-organic fertilisation was applied. Humin acids obtained from the soils fertilised with Humidol (Table 1) can be classed as humus compounds with lower degree of maturity according to the so-far conducted studies on E4/E6 [3,10]. A considerable increase in their amount following Humidol fertilisation and lower mobility of this group of combinations can decide on their cummulation in the Ap horizon. That creates suitable conditions for their relatively permanent increase in the humus content of the sandy soils. The above has been confirmed by the studies of Maciejewska [18] who used “R complement” do improve the properties of sandy soils and reports by other researchers [6,16].

Components of Humidol Standard contain high quantities of organic matter with high degree of humification and considerable amounts of Ca and Mg that improve physicochemical soil properties. This is manifested by an increase of sorption capacity, degree of sorption complex saturation with basic cations and lowering of ion concentration that results their acidity.

Pondel [19] reported without any doubts that sandy soils are poor in nutrients. Combined effects of mineral fertilisation and Humidol application resulted in a significant increase in the available P, K, and Mg forms in these soils.

In the LGOM district, heavy metal content plays an important role in the fertility level of soils. Now and then, considerable amounts of these elements are found in the soils locally. Then it is necessary to exclude such soils from agricultural utilisation [4,21]. Under the influence of Humidol Standard fertilisation, an increase of Pb and Zn, and especially their available forms in the soil was found.

On the basis of the so-far conducted studies [7,8,11,22] it can be said that application of organic fertilisers, liming and fertilisation with phosphorus, results in the lowering of phyto-availability of heavy metals, which is caused, among others, by the lowering of their solubility [2]. Results of studies on the content of Pb and Zn forms soluble in 1M HCl do not confirm this hypothesis. The amount of soluble Pb and Zn forms in the objects fertilised with Humidol Standard and mineral fertilisers were higher in the case of phosphorus than in the control 0 combination. Earlier studies on potato tubers carried out by Prośba-Białczyk and Mydlak in 1997 [20] showed lower content of Pb and Cd in the tubers in the second year of growing. It shows that the amount of heavy metal forms soluble in 1 M HCl does not always reflect their phyto-availability. In the areas where the influence of cooper industry is significant, the content of these heavy metal forms is a considerable part of the total forms [14]. In the light of studies by Karczewska *et al.* [14], determination of phyto-available forms of heavy metals on the basis of their solubility in 1 M HCl does not fully reflect the amount of these forms uptaken by plants, since the above solution is one of the most aggressive extractants.

CONCLUSIONS

1. Fertilisation with Humidol Standard results in a quick growth of organic matter, improvement of the humic compounds quality and physicochemical properties of sandy soils.

2. Application of Humidol Standard in combination with NPK fertilisation can be a safe agrotechnical treatment that improves fertility of sandy soils in the LGOM district in a short period of time.

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