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THE DEGRADING EFFECT OF AGROTECHNICAL MEASURES ON THE REACTION AND CHEMICAL PROPERTIES OF SOIL*

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A b s t r a c t. Brown soils formed from silt loess-like formation occurring in the Lublin Upland were examined. It was attempted to evaluate the effect of various agrotechnical measures on the chemical degradation of soil (reaction, sorptive capacity as well as available P_2O_5, K_2O and Mg content) in the objects which had been agriculturally utilized for many years.

The high NPK fertilization without liming combined with intensive plant protection caused distinct drop of reaction and the deterioration of sorptive capacity. Especially strong chemical degradation was noted in the soil of herbicide fallow strips both in fertilized and non-fertilized objects.

K e y w o r d s: soil chemical degradation, agrotechnical measures, land use

INTRODUCTION

The literature on the effect of intensive mineral fertilization on the acidification of soil is comparatively large [1,2,4,5,9,10]. It is known that the drop of reaction causes changes in the availability of basic macro- and microelements [1,2,6,13] as well as the change in the sorptive capacity [4]. The application of the plant pesticides also contributes to drop of soil reaction [11]. However, not many papers discuss simultaneous effect of many agrotechnical factors, such as intensive NPK fertilization, intensive plant protection and the way of land use on the reaction and basic chemical properties of soil [1].

That is why an attempt was made to evaluate the effect of long-term application of various agrotechnical measures on the chemical degradation of soil.

MATERIALS AND METHODS

Brown soils formed from silt, loess-like formations occurring in the Lublin Upland were examined. The following objects were comprised in the research:

A - a permanent field, on which a 6-field crop rotation of the following plants: potatoes on farm manure, spring barley with the companion crop of red clover, red clover, winter wheat, broad bean and winter rye was applied. The mineral fertilization and plant pesticides were adjusted to the demands of respective plants. Samples were taken from the field of winter wheat. This object was treated as the control one compared to the other ones. This object is the experimental field of the Agricultural Meteorology Department of the University of Agriculture in Lublin.

B - apple-tree orchard - 20 years old, of Jonathan variety having been in a 12 years long fertilization experiment of the Pomology

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Department of the University of Agriculture in Lublin. The samples were collected from the grass strips and herbicide fallow from the following fields:

1. fields having been fertilized with 525 kg NPK/ha for 12 years, and
2. fields which have not been fertilized for 12 years.

C - productive field of the Agricultural Experimental Station in Lublin. Full mineral fertilization adjusted to the needs of the respective plants is being applied in the farm. The applied crop rotation is the following: potatoes on the farm manure, spring wheat with the companion crop of lucerne, winter rape and winter wheat. Samples were taken from the lucerne field in the first year of the cutting.

D - the field in a farm of low level of agrotechnics and low mineral fertilization. In this farm no permanent crop rotation was applied. The samples were taken from the field of winter wheat.

E - mixed forest in the natural habitat.

In the all above mentioned objects, soil samples were taken from the Ap (2-7 cm and 12-17 cm) horizon of soil as well as from the horizon B (25-30 cm).

The following analyses were carried out:

- the total C content with the Tiurin's method,
- pH - electrometrically in 1 mol/dm^3 KCl,
- hydrolytic acidity with the Kappen's method,
- the sum of cations with the Kappen's method,
- the available phosphorus and potassium with the Egner-Riehm's method,
- available magnesium with Schachschabel's method.

RESULTS AND DISCUSSION

The reaction of the analysed soils shows their significant acidification independently of the way of their utilization. The highest acidification in the whole profile showed the forest soil (pH in 1mol/dm^3 KCl -3.7).

Almost identical acidification was noted in the soil from herbicidal strips from perennial apple tree orchard (Table 1). In both the objects the pH of soil was within the range of very acid reaction. In the grass strips situated near the discussed objects the acidification was significantly lower, as the pH of soil was higher by one unit than in the analysed layers of the herbicide strip. These results show the unfavourable effect of herbicidal strips on the properties of soil and the favourable effect of grass strips. In case of the grass strips, intensive fertilization with NPK caused the drop of pH by one unit in the layer 2-7 cm, which proves that in spite of generally favourable effect of grass on the properties of soil, the intensive mineral fertilization without liming unfavourably influences the soil reaction and is degradation processes.

The results discussed above entirely correspond with the analyses of the composition and properties of humic compounds carried out in these objects [3]. In the quoted work it was stated that in the soil from herbicide fallow, both comparing to the cultivated field and to the grass strip, a significant decrease in the total C content proceeded as well as distinct decrease in the quality of humic compounds, which is one of the basic indices of the chemical degradation processes of soil [8].

The soil from the field in extensive farm was significantly acidified (pH<4.8) which proves that liming was not applied there. The changes of reaction are reflected in sorptive properties including hydrolytic acidity, the sum of exchangeable cations and the degree of base saturation of the sorptive complex. For example, in the forest soil, the base saturation amounted to 17.9 %, in the soil from herbicide strip with high NPK fertilization it was 18.9 %, at the same time in the soil from grass strip without fertilization 80.8 %, in the permanent field 51.1 % and in the productive Agricultural Experimental Station field (RZD field) - 71.9 %.

The hydrolytic acidity ranged from 10.35 mmol H^+/100 g in the forest soil to 1.92 mmol H^+/ 100 g of soil in the grass strip without fertilization. In the apple-tree orchard in the herbicide strip with high NPK fertilization, soil contained only 1.4 mmol(+)/100 g soil of basic cations, while in the grass strips without fertilizing 8.1 mmol(+)/100 g of soil.

Table 1. Basic chemical properties of the soils studied

Object	Genetic horizon	Sampling depth (cm)	Total C (mg/100 g)	pH KCl	mmol(+)/ 100 g soil			V (%)
					H	S	T	
1. Permanent field	Ap	2-7	976	4.9	3.77	3.95	7.72	51.1
		12-17	984	4.8	3.46	4.15	7.61	54.5
	(B)	25-30	177	4.9	1.95	8.65	10.60	81.6
2. Apple-tree orchard								
a) *	Ap	2-7	760	3.6	6.00	1.40	7.40	18.9
		12-17	832	4.7	3.14	4.20	7.34	57.2
	(B)	25-30	192	5.7	1.37	5.70	7.07	80.6
b)	Ap	2-7	60	3.8	4.43	3.45	7.88	43.7
		12-17	517	4.1	3.42	3.60	7.02	51.2
	(B)	25-30	184	4.9	1.80	8.80	10.60	83.0
c)	Ap	2-7	1 144	4.9	3.79	5.50	9.29	59.2
		12-17	728	6.1	1.69	6.38	8.07	79.0
	(B)	25-30	224	6.1	1.24	10.36	11.60	89.3
d)	Ap	2-7	1 032	5.8	1.92	8.10	10.02	80.8
		12-17	592	5.9	1.46	7.20	8.66	83.1
	(B)	25-30	288	5.6	1.46	8.80	10.26	85.8
3. Experimental Station field	Ap	2-7	928	5.3	2.61	6.70	9.31	71.9
		12-17	744	5.7	2.07	7.30	9.37	77.9
	(B)	25-30	216	5.6	1.58	9.90	11.48	86.2
4. Extensive field	Ap	2-7	924	4.8	3.42	4.65	8.07	57.6
		12-17	864	4.7	3.64	4.80	8.44	56.8
	(B)	25-30	128	3.8	3.87	6.70	10.57	63.3
5. Forest	Ap	2-7	2 416	3.7	10.35	2.25	12.60	17.9
		12-17	936	3.7	7.20	0.25	7.45	3.4
	(B)	25-30	168	3.7	3.79	2.65	6.44	41.4

*a) herbicide strip+high NPK; b) herbicide strip without fertilization; c) grass strip+high NPK; d) grass strip without fertilization.

In the soils utilized in a typically agricultural way, the highest value of basic cations - 6.7 mmol(+)/100 g of soil was noted in the productive RZD field, which testifies to the proper level of fertilization.

The total sorptive capacity in the tested objects was similar and within the range from 7.4 mmol(+)/100 g of soil in the fertilized herbicide strip to 12.6 mmol(+)/100 g in the forest soil.

The available phosphorus content in the examined soils was differentiated. The differentiation of the availability of this component was distinctly correlated with the intensity of farming and the level of fertilization. On the basis of the limit numbers for Egner-Riehm method [14], the soils from the established field and the RZD field should be numbered among the ones of high availability in P_2O_5, the ones from the field extensively utilized among the soils with medium availability, and the forest soil among the ones of low availability in this element. In the fertilized apple-tree orchard high content of P_2O_5 was noted and in the non-fertilized one both in the grass strip and herbicide strip this availability was low (Table 2).

On the basis of limit numbers for Egner-Riehm,s method the examined soils in the intensively fertilized orchard could be numbered among the ones with very high availability in potassium, the soil from the established field to very high availability, the soil from the RZD field and the extensive one to the medium availability and soil from the non-fertilized herbicide strip as well as the forest soil to the low availability in this element. The soil from the grass strips non-fertilized with NPK had very low availability which might have been caused by a considerably higher reaction of these soils which, as it is known, gives conditions for the increase in this element uptake by the plants [7,11].

Table 2. Content of available P, K, and Mg in the soils studied

	Object	Genetic horizon	P_2O_5	K_2O	Mg
			mg/100 g soil		
1.	Permanent field	Ap	15.3	21.6	5.4
		(B)	6.6	5.0	7.4
2.	Apple-tree orchard				
	a) herbicide strip	Ap	16.7	44.7	3.4
	+ high NPK	(B)	6.7	5.0	5.3
	b) herbicide strip	Ap	7.4	10.0	2.4
	without fertilization	(B)	5.5	4.0	4.0
	c) grass strip+high NPK	Ap	16.8	44.7	3.0
		(B)	5.4	5.7	5.7
	d) grass strip without	Ap	5.1	3.3	4.3
	fertilization	(B)	5.4	3.7	3.5
3.	Experimental Station	Ap	19.4	14.6	7.4
	field	(B)	9.1	5.0	11.0
4.	Extensive field	Ap	12.1	16.8	4.5
		(B)	6.0	10.0	6.7
5.	Forest	Ap	2.8	7.6	3.5
		(B)	4.4	3.7	7.4

As it is in the case of phosphorus, the available potassium content in soil is influenced by mineral fertilization.

On the basis of limit numbers [14] the analysed soils from RZD field can be numbered among the ones with high available magnesium content. The soil from the control field showed medium availability. The remaining soils are the ones with low or very low availability in this element. In all the fields higher magnesium content was noted in (B) horizons than in humic horizons. As it is generally known, magnesium belongs to the elements most strongly exhausted from soil by highly cropping vegetation [1,6], which, in case of the lack of additional magnesium fertilization, resulted in a very low availability of this element in soil.

CONCLUSIONS

The carried out research showed a considerable influence of long-term utilization of soil on its chemical properties. This influence was manifested with strong acidification of soil in the herbicide strips of orchards.

As the results of intensive mineral fertilization and permanent application of herbicides for weed control and grasses, the decrease in the amount of humic compounds and their quality proceeded as well as many other unfavourable phenomena occurred such as: strong acidification of soil, the increase in soil acidity, the decrease in sorptive capacity and multiple decrease of the saturation with alkaline cations comparing to the soils from fields with typical cultivation and the soils in the grass strips.

The obtained results univocally prove the occurrence of strong degradation processes as the result of the application of intensive mineral fertilization combined with applying herbicides for weed control in the orchard.

REFERENCES

1. **Czuba R., Nurzyński J.:** Zmiany w zawartości składników pokarmowych w sianie i glebie łąkowej w okresie 15-letniego intensywnego nawożenia mineralnego. Plony i zmiany właściwości gleb. Roczn. Glebozn., 39(4), 245-264. 1988.
2. **Doboszyński L., Rybak K., Ziemlewska G.:** Wpływ wieloletniego nawożenia pastwiska nawozami mineralnymi na roślinność i glebę. Skutki wieloletniego stosowania nawozów. Cz.1. IUNG Puławy, 1976.
3. **Domżał H., Flis-Bujak M., Baran S., Żukowska G.:** Wpływ użytkowania sadowniczego na materię organiczną gleby utworzonej z utworów pyłowych. Zesz. Probl. Post. Nauk Roln., (in press).
4. **Gorlach E., Curyło T.:** Wpływ odczynu gleby na pobieranie potasu, sodu, magnezu i wapnia przez różne gatunki roślin. Roczn. Glebozn. 41(1/2), 117-131 1990.

5. **Kern H.:** Odczyn i zawartość węglanu wapnia w glebach użytków rolnych Polski. Pam. Pul., 85, 189-196. 1985.
6. **Mercik S., Goralski J., Gutyńska B.:** Badania nad współdziałaniem potasu z magnezem i wapnem na różnych glebach i pod różnymi roślinami. Cz.I. Zmiany w niektórych cechach żyzności gleb po kilkuletnim nawożeniu. Roczn. Glebozn., 35(1), 49-60, 1984.
7. **Mercik S.:** Wpływ odczynu na plonowanie roślin i na efektywność nawożenia potasu. Roczn. Glebozn., 38(2), 111-123, 1987.
8. **Oldeman L.R.:** Global extent of soil degradation. Proc. Int. Conf. 'Soil Resilience and Sustainable Land Use'. Budapest, 1992.
9. **Rabikowska B., Wilk K.:** Wpływ wieloletniego nawożenia obornikiem i azotem na właściwości gleby gliniastej. Cz.I. Odczyn gleby oraz zawartość węgla i azotu. Roczn. Glebozn., 42(3/4), 27-35, 1991.
10. **Sirowy V.:** Vliv vysokych davek hnojiv na acidifikaci pud. Rostl. Vyroba, 25(7), 755-762, 1979.
11. **Szwedo J.:** Wpływ zróżnicowanych dawek Gesatopu 50 i nawożenia azotowego na wzrost, plonowanie i zawartość składników mineralnych w liściach porzeczki czarnej odmiany Roodknop oraz w glebie. Ph.D.Thesis, AR Lublin, 1984.
12. **Terelak H., Fotyma M.:** Wpływ nawożenia potasem na zawartość form tego składnika w glebach i ich pobieranie przez rośliny. Roczn. Glebozn., 37(1), 203-213, 1986.
13. **Turski R., Wójcikowska-Kapusta A., Martyn W., Kaniuczak J.:** Wpływ sposobów użytkowania na właściwości chemiczne i zawartość mikroelementów w glebach wytworzonych z lessów. Zesz. Nauk. AR Wrocław, Rolnictwo, 53, 196, 47-54, 1990.
14. Zalecenia nawozowe. Cz.I. IUNG Puławy, 29, 1985.

DEGRADUJĄCY WPŁYW INTENSYWNYCH ZABIEGÓW AGROTECHNICZNYCH NA ODCZYN I WŁAŚCIWOŚCI CHEMICZNE GLEB

Badaniami objęto gleby brunatne wytworzone z utworów pylowych, lessopodobnych występujących na Wyżynie Lubelskiej. W pracy podjęto próbę oceny wpływu różnorodnych zabiegów agrotechnicznych na degradację chemiczną gleb (odczyn, pojemność sorpcyjna oraz zasobność w przyswajalny P_2O_5, K_2O i Mg) na obiektach użytkowanych rolniczo przez wiele lat.

Wysokie nawożenie NPK bez wapnowania, połączone z intensywną ochroną roślin powodowało wyraźny spadek odczynu i pogorszenie zdolności sorpcyjnych. Szczególnie silną degradację chemiczną stwierdzono w glebie pasów herbicydowych i to zarówno na obiektach nawożonych, jak i nienawożonych.

S ł o w a k l u c z o w e: chemiczna degradacja gleb, zabiegi agrotechniczne, użytkowanie ziemi.