ЕКОЛОГІЧНІ ДОСЛІДЖЕННЯ ГЕОСИСТЕМ

UDC 630*114.2

A. LISNYAK, assist. prof., PhD.,
V. N. Karazin Kharkiv National University
6 Svobody Sq., 61077, Ukraine
Ukrainian Research Institute of Forestry and Forest Melioration named after G. M. Vysotsky
Pushkinska st. 86, Kharkiv, 61024, Ukraine
laa.79@mail.ru

S. TORMA, PhD.
National Agricultural and Food Centre, Soil Science and Conservation Research Institute Bratislav regional work place Presov, Raymannova st. 1, 080 01 Prešov, Slovak Republic

AGROECOLOGICAL RESEARCH OF PH VALUE IN ACIDIC SOILS AT LIMING ABSENCE

Purpose. Agroecological research of soil pH value in acidic soils at liming absence on agricultural lands. **Methods.** To determine of soil pH value in acid soils used electrometer (potentiometric) method. **Results.** Soil investigation oriented to soil reaction study took place on Slovak farms Nemšová and Osikov in 2010 and repeated after four years again. In the agricultural enterprise Nemšová neutral and alkaline soil acreage (pH value above 6.6) decreased from 1008 ha to 190 ha in period 2010-2014 (decrease 82 per cent) and contrary soil acreage with pH value below 5.5 increased from 274 ha to 569 ha in the same period. In the agricultural enterprise Osikov acreage with pH value above 6.6 was reduced in period 2010-2014 from 1548 ha to 178 ha (decrease 90 per cent), while acid and strong acid soils (pH lower than 5.5) increased from 138 ha to 838 ha in the same period. **Conclusions.** It confirmed that liming absence resulted in soil reaction rapid decrease in natural way - by calcium and magnesium resorption with crops, their leaching into deeper soil horizons, their outflow with erosion but also with acid rains impact or physiologically acid fertilization.

Keywords: soil reaction, pH, agroecological research, liming absence

Лісняк А.
Харківський національний університет імені В. Н. Каразіна
Український науково-дослідний інститут лісового господарства та агролісомеліорації імені Г. М. Висоцького
Торма С.
Братиславський науково-дослідний інститут ґрунтознавства та охорони грунтів

АГРОЕКОЛОГІЧНЕ ДОСЛІДЖЕННЯ РН СЕРЕДОВИЩА В КИСЛИХ ҐРУНТАХ ЗА ВІДСУТНОСТІ ВАПНУВАННЯ

Мета. Агроекологічне дослідження на сільськогосподарських землях значення pH середовища в кислих ґрунтах при відсутності вапнування. **Методи.** Для визначення pH середовища в кислих ґрунтах використовувався електрометричний (потенціометричний) метод визначення. **Результати.** Вивчення реакції середовища в ґрунтах проведено на словацьких фермах Немшова і Осіков в 2010 році та повторно проведено через чотири роки. В сільськогосподарському підприємстві Немшова площі нейтральних і лужних ґрунтів (pH вище 6,6) в період 2010-2014 рр. скоротилися з 1008 га до 190 га (82% зниження) і навпаки посівних площ з pH ґрунтів нижче 5,5 збільшилися з 274 га до 569 га за цей же період. В сільськогосподарському підприємстві Осіков площі зі значенням pH вище 6,6 скоротилися в період 2010-2014 рр. з 1548 га до 178 га (зниження на 90%), в той час як сильно кислі і кислі ґрунти (нижче pH 5,5) збільшилися з 138 га до 838 га за цей же період. **Висновки.** Підтверджено, що відсутність вапнування призвело до швидкого зниження реакції ґрунтового середовища природним чином – за рахунок виносу кальцію і магнію культурами, їх вилуговуванням в більш глибокі горизонти ґрунту, їх змив з ерозією, а також з кислотним впливом дощів або фізіологічно кислих добрив.

Ключові слова: ґрунтової реакції, pH, агроекологічне дослідження, відсутність вапнування

Лисняк А.
Харьковский национальный университет имени В. Н. Каразина
Харьковский научно-исследовательский институт лесного хозяйства и агролесомелиорации имени Г. Н. Высоцкого
Торма С.
Научно-исследовательский институт почвоведения и охраны почв в *Братиславе*

АГРОЭКОЛОГИЧЕСКОЕ ИССЛЕДОВАНИЕ РН СРЕДЫ В КИСЛЫХ ПОЧВАХ ПРИ ОТСУТСТВИИ ИЗВЕСТКОВАНИЯ

Цель. Агроэкологическое исследование на сельскохозяйственных землях значения pH среды в кислых почвах при отсутствии известкования. Методы. Для определения pH среды в кислых почвах использовался электрометрический (потенциометрический) метод определения. Результаты. Изучение реакции среды в почвах было проведено на словацких фермах Немшова и Осиков в 2010 году и повторно проведено через четыре года. В сельскохозяйственном предприятии Немшова площади нейтральных и щелочных почв (pH выше 6,6) в период 2010-2014 годов сократились с 1008 га до 190 га (снижение 82 %) и наоборот посевных площадей с pH почв ниже 5,5 увеличилось с 274 га до 569 га за этот же период. В сельскохозяйственном предприятии Осиков площади со значением pH выше 6,6 сократились в период 2010-2014 годов с 1548 га до 178 га (снижение на 90 %), в то время как сильно кислые и кислые почвы (pH ниже 5,5) увеличились с 138 га до 838 га за этот же период. **Выводы.** Подтверждено, что отсутствие известкования привело к быстрому снижению реакции почвенной среды естественным образом – за счёт выноса кальция и магния культурами, их выщелачиванием в более глубокие горизонты почвы, их смыв с эрозией, а также с кислотным воздействием дождей или физиологически кислых удобрений.

Ключевые слова: почвенная реакция, pH, агроэкологическое исследование, отсутствие известкования

Introduction

Soil reaction, as one of basic agrochemical soil properties, reflects the properties of most active gentledispersed soil fractions, particularly their ratio of basic cations saturation to hydrogen. Formation of qualitative and quantitative ratios of soil saturation is result of interactive action of all factors in soil development process.

Acid soil reaction has many negative phenomena with impact both on soil itself and crop grown. Some of them are mentioned bellow:

- very acid soil reaction brings about phosphorus chemical fixation and phosphorus is not available for plants;
- potassium is less fixed with soil at low soil pH value and it is easier washed out of soil horizons. These two phenomena are resulting into mentioned nutrients lower uptake by plants that is not beneficial, particularly at parallel limited fertilization with these nutrients;
- the microelement uptake with plants is various in dependence on soil pH value, e.g. iron, manganese and copper mobility increases in acid environment, but molybdenum, that positively influences on rhizobial bacteria development, is almost infunctional in environment with pH under 5.0;
- lower soil pH value supports heavy metals mobility that easier enter crops as well as food chain [1, 3];
- humus quality decreased at acid soil reaction due to low ratio of humic acids to fulvic acids [4, 6];
- acid soils have not stable structure and easily undergo erosion [5, 6];
- biological activity of acid soils is low, because all useful microflora and microfauna perishes. Therefore nitrification ability is low, cellulose decomposition is of small intensity and extent of breathing in soil is decreased.

Material and methods

As marked example of soil acidification at zero liming, two agricultural enterprises were chosen. They are Agricultural Co-operative (PD) Osikov (north-east of Slovakia) and Agricultural Co-operative (PD) Nemšová (west of Slovakia).

Soil forming substratum in PD Osikov territory is Carpathian Flysch in typical development that is composed of sandstones alternated with slate and sandy mudstones. Quartenary is represented with deluviums and solifluction looms with majority of deluviums. All the groups of deluvial sediments have, as a rule, acid character and are mixed with the skeleton of flysch rocks. Holocene is located in drainage area of the Sekčov brook and in drainage area of other brooks. It is built of non calcareous to weak calcareous alluvial sediments of variable depth and texture. Main soil types are Dystric Planosols, Cambisols and Rankers.

In the PD Nemšová territory soil forming substrata in alluviums of the rivers Váh and Vlára are Holocene sediments most carbonate. There are loam of loess, Mesozoic slates and dolomitic limestone in hilly land part of the territory. Main soil representatives are here dystric Planosols, Luvisols and Cambisols.

This paper was elaborated based on the newest analytic data of soil solution pH (sampled in 2014), the values were compared with former pH value (2010). Noticeable is that in period of four years there was no application liming materials. Soil reaction change runs in normal way, under influence of paternal rocks, acid precipitation and calcium ions resorption with biomass.

Results and discussion

Factors affecting soil reaction. Soil reaction is under influence of inner and outer factors. *Inner (endogenous) factors* are including particularly rock chemism and texture (parental material).

Outer factors include:

atmospherical factors - precipitation that penetrate into soil and leach substances effecting soil puffering capacity, as well as soil reaction stability;

biological factors - plant remainders and root secrets that are source of hydrogen ions. Here can be also included calcium and magnesium uptake by plants. Every crop needs these nutrients for its growth in smaller or larger extent as important constituent of its nutrition. Plants resorb mentioned nutrients in period of their active growth, whereby individual species have different demands (see Table 1) [2];

anthropic factors - soil acidification processes are considerably supported by acid atmospheric deposits with main compound sulphuric oxide. This is main contribution to calcium leaching after its natural dynamics in soil.

Fertilization belongs to other unneglegible factor of soil reaction decrease. Although recently was fertilizer use substantially reduced, particularly phosphorus and potassium ones, it is necessary to realize that most nitrogen fertilizers are physiologically acid (Table 2 – according to Sluismans), therefore their acidification impact should be neutralised.

Table 1

Calcium and magnesium output by some plants

Crop	**Ca and Mg output with 1 ton of main product with by-product (kg)**			
	CaO	**Ca**	**MgO**	**Mg**
Winter wheat	4 - 6	2.8 - 4.3	4 - 6	2.4 - 3.6
Spring barley	8 - 10	5.7 - 7.1	4 - 6	2.4 - 3.6
Oats	9 - 11	6.4 - 7.9	6 - 8	3.6 - 4.8
Triticale	6 - 9	4.3 - 6.4	5 - 7	3.0 - 4.2
Winter rape	50 - 70	35.7 - 50.0	8 - 11	4.8 - 6.6
Legumes	25 - 40	18 - 28.5	5 - 10	3.0 - 6.0
Sugar beet	3 - 5	2.1 - 3.6	2 - 3.5	1.2 - 2.1
Potatoes	1.1 - 1.5	0.8 - 1.1	0.4 - 1	0.25 - 0.6
Silage maize	4 - 6	2.8 - 4.3	0.3 -0.6	0.2 - 0.6
Corn maize	7 - 9	5.0 - 6.4	8 - 10	4.8 - 6.0
Alfalfa	4 - 6	2.8 - 4.3	0.5 - 1	0.3 - 0.6
Red clover	4 - 6	2.8 - 4.3	0.5 - 1	0.3 - 0.6

Farmyard manure reduced application contributes to soil acidification, too. As it is well known organic biomass has buffering effect on the processes of acidification by its increase soil buffering capacity.

Soil reaction is linked with Ca^{2+} and Mg^{2+} compounds presence in soil forming substrata (particularly carbonates). In conditions of their surplus soils have alkaline reaction and contrary soil acidity is linked with mentioned compounds absence.

Primary acid soil originated of acid rocks that are minerally poor (no or less basic compounds), are not able to neutralise quickly enough hydrogen ions of organic, mineral, biotic or abiotic origin.

Acidification could be happen also in secondary way, including substrata containing basic compounds, particularly when located in climatic regions with higher precipitation and soluble acid compounds (CO_2, fertilizers, acid pollutants etc.) Under these influences calcium and magnesium compounds are released and are leached into lower soil horizons.

Table 2

Calcium equivalent at some fertilizer application

Fertlizers	**CaO loss or gain**	
	per 100 kg of fertilizer	**per 100 kg N**
Ammonium sulphate	- 63	- 299
Ammonium nitrate with limestone	- 16	- 58
Urea	- 46	- 100
Kalkamid	+ 35	+ 81
Waterless ammonium	- 82	- 100
Superphosphate (18 %)	0	0
Potassium salts and kieserit	0	0

Soil reaction status in observed farms. At generally well known soil categorisation by soil reaction in 2010 PD Osikov registered only 6.8 per cent soil with pH value under 5.5, almost one half of arable land was neutral and more than one fourth was alkaline (pH 6.6 - 7.2). After the four years, when liming materials were markedly limited, pH value shift toward acid reaction takes place. Liming materials application was totally absented at PD Osikov. This was reflected in new distribution of arable land according to pH values (Table 3, Figure 1).

Table 3

The soil pH value in farm Osikov

Soil sampling Year	**Share of soils**	**Soil pH value pH/KCl in arable land**					
		< 4.5	**4.6 - 5.0**	**5.1 - 5.5**	**5.6 - 6.5**	**6.6 - 7.2**	**> 7.2**
2010	ha	27	34	77	408	963	585
	per cent	1.4	1.7	3.7	19.5	46.0	27.9
2014	ha	60	150	628	532	178	0
	per cent	3.9	9.7	40.8	34.0	11.6	0

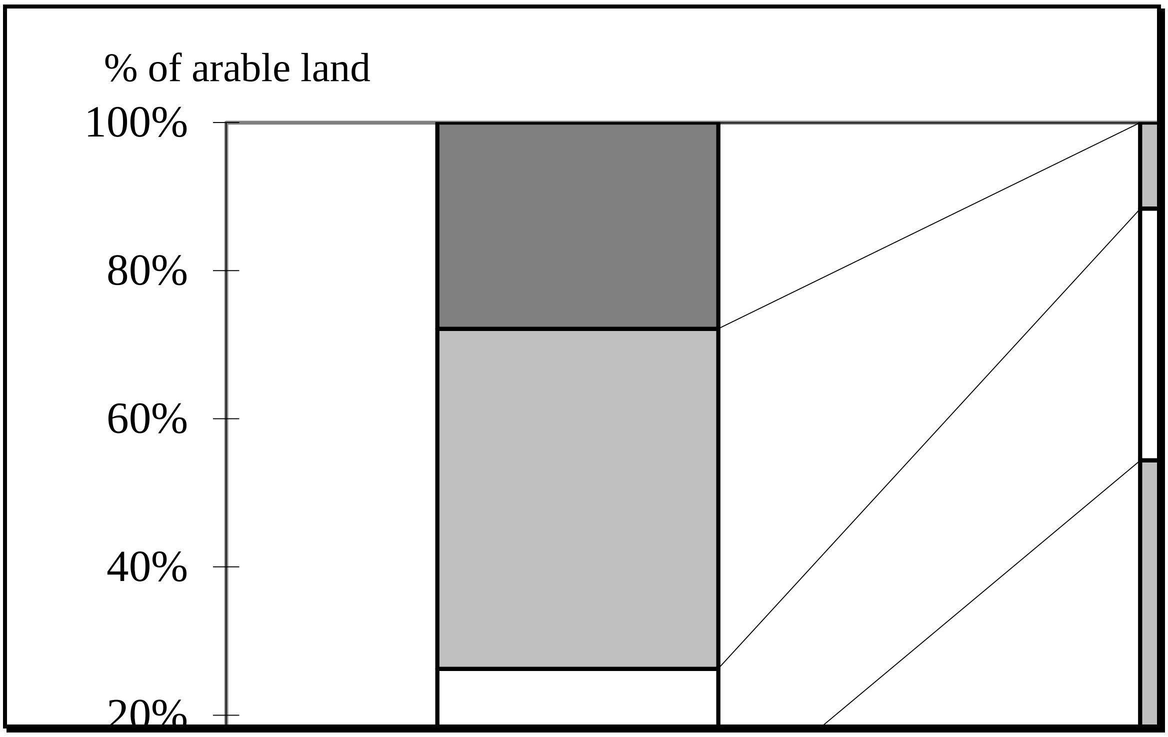

Figure 1 – The change of soil pH value during four years in farm Osikov

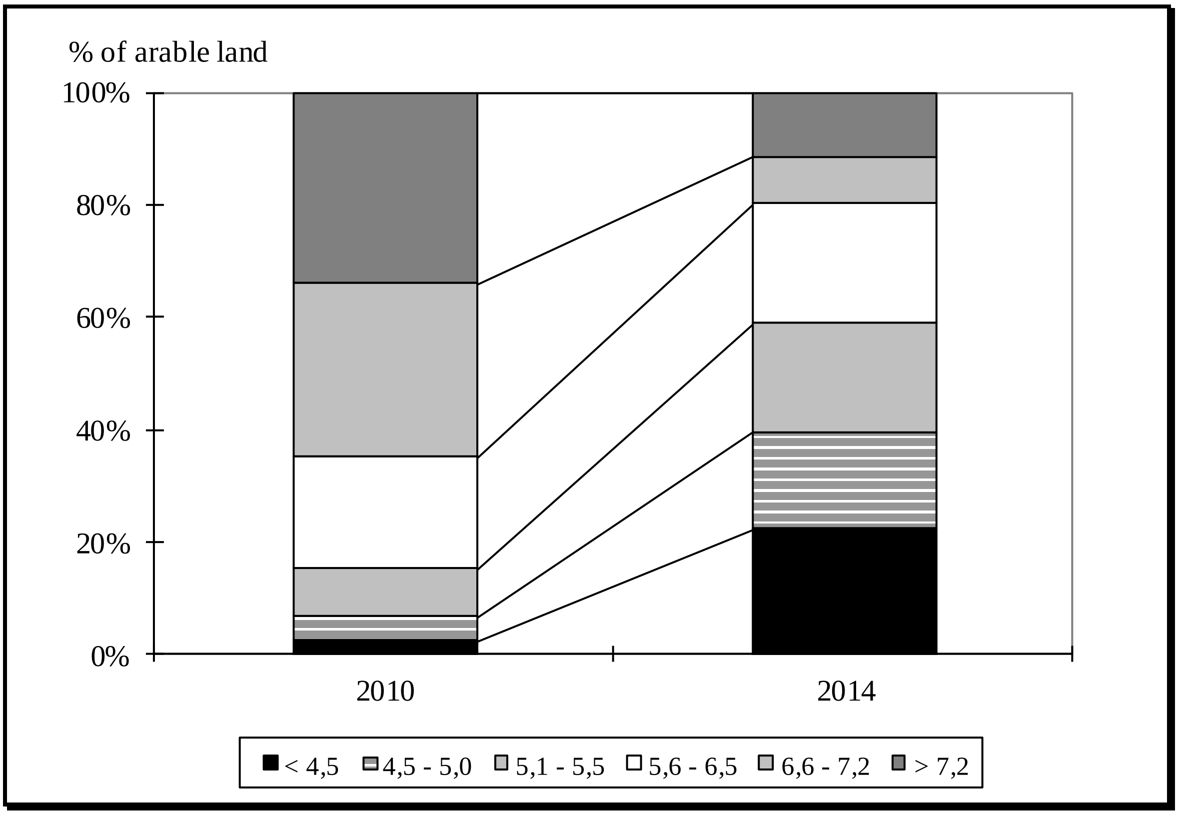

Figure 2 – The change of soil pH value during three years in farm Nemšová

Table 4

The soil pH value in farm Nemšová

Soil sampling Year	**Share of soils**	**Soil pH value pH/KCl in arable land**					
		< 4.5	**4.6 - 5.0**	**5.1 - 5.5**	**5.6 - 6.5**	**6.6 - 7.2**	**> 7.2**
2010	ha	43	76	155	365	557	451
	%	2.6	4.6	9.4	22.1	33.8	37.5
2014	ha	217	165	187	208	80	110
	%	22.4	17.1	19.3	21.5	8.3	11.4

There was almost 55 per cent of arable land in the category extreme acid, strong acid and acid with pH value lower than 5.5 in 2014. Minimum pH value within the entire farm is 3.6. From Figure 1 is visible that soils with pH above 5.6 (in 2010 belonged here almost all arable land) cover only 45.6 per cent.

The co-operative farm Nemšová showed similar trend in soil reaction evolution in recent four years - non beneficial. Liming materials limited application in recent years resulted in substantial decrease of soil area with alkaline and neutral reaction and vice versa increases of acid soil area, strong acid and extreme acid soils. From table 4 and Figure 2 is visible that soil share with pH under 4.5 (extreme acid) increased from 2.6 per cent even to 22.4 per cent.

Similarly was increased also share of soils with strong acid and acid reaction so within last Agrochemical Soil Testing we have registered in PD Nemšová almost 60 per cent soil with pH value lower than 5.5. Share of neutral soils decreased from 33.8 per cent to present 8.3 per cent of total area. From this trend is possible to form a picture, what could happen when liming material application remains neglected.

Conclusion

There is a shocking situation from the point of view of soil reaction on both mentioned farms. Areas of soil categories with alkaline and neutral soil reaction were reduced markedly and proportion of acid, strong acid and extreme acid soil reaction (soils with pH value lower than 5.5) increased. This process runs in natural way - leaching and washing out calcium cations, acid character of plant remainders, and calcium natural resorption by crops.

The share of alkaline and neutral soils (pH above 6.6) was reduced in the agricultural enterprise Nemšová from 1008 ha in 2010 to 190 ha in 2014 and contrary the acidity category with pH value lower than 5.5 increased from 274 ha in 2010 to 596 ha in 2014.

Similar situation is also in agricultural enterprise Osikov. Soil acreage with pH value above 6.6 decreased in period three years from 1548 ha to 178 ha, vice versa acid and strong acid soils acreage (pH value lower than 5.5) increased from 138 ha in 2010 to 838 ha in 2014.

Summary

Soil investigation oriented to soil reaction study took place in two agricultural enterprises in 2010 and it was repeated after four years again. The pH value change at total absence of liming was balanced. It was confirmed that liming absence resulted in soil reaction rapid decrease in natural way - by calcium and magnesium resorption with crops, their leaching into deeper soil horizons, their outflow with erosion but also with acid rains impact or physiologically acid fertilization.

In the agricultural enterprise Nemšová neutral and alkaline soil acreage (pH value above 6.6) decreased from 1008 ha to 190 ha in period 2010-2014 (decrease 82 per cent) and contrary soil acreage with pH value below 5.5 increased from 274 ha to 569 ha in the same period.

There is even more unbeneficial situation in the agricultural enterprise Osikov. Acreage with pH value above 6.6 was reduced in period 2010-2014 from 1548 ha to 178 ha (decrease 90 per cent), while acid and strong acid soils (pH lower than 5.5) increased from 138 ha to 838 ha in the same period.

Acknowledgements. This work was supported by the Slovak Research and Development Agency under contract No. APVV-15-0406 and APVV-0131-11.

Literature

1. Bruess A., Turian G., Noltner D., Schweikle H. Hintergrundwerte substrate-, gesamthalte- und mobile Anteile // Mitteilungen der Bodenkundlichen Gesellschaft, vol. 76, 1995. – pp. 1461-1464.
2. Czuba R., Fotyma M., Glas K., Andres E. Potas - skladnik decydującyśo wielkośti i jakości plonów // IPI - Research Topics No. 16, International Potash Institute, Basel, 1994. – 56 pp.
3. Kollektiv: Die Düngung von Acker- und Grünland nach Ergebnissen der Bodenuntersuchung. Bayerische Landesanstalt für Bodenkultur und Pflanzenbau, München, Bayerishce Hauptversuchsanstalt für Landwirtschaft und Institut für flanzenernährung der TU München, Freising-Weihenstephan, 1985. – 36 pp.
4. Masaryk Š., Hraško J., Bábek R. Vápnenie pôd. Príroda – Bratislava, 1980, 185 s.
5. Neuberg, J., Jedlička J., Červená H. Výživa a hnojení plodin. Metodika ÚZPI Praha / J. Neuberg,. – Bratislava, 1995. – 64 s.
6. Torma S., Lisnyak A. Comparison of variability of soil acidity of agricultural farms in Slovakia// Людина і довкілля. Проблеми неоекології. 2011. №1-2. С. 113-118. – ISBN 1992-4224.

Надійшла до редколегії 03.10.2016