SOIL REACTION AND SUGAR BEET
Influence of Soil Liming and Rapid Effectiveness of Composite Humino-Calcium Soil Preparations on Soil pH Change

Pôdna reakcia a cukrová repa
Vplyv vápnenia a rýchlej účinnosti kompozitných humino-vápenatých pôdnych preparátov na zmenu pH pôdy

Ing. Štefan Tóth, PhD., Ing. Božena Šoltysová, PhD., Ing. Pavol Porvaz, PhD.
NPPC – Výskumný ústav agroekológie Michalovce

Abstract

The presented work is focused on summarizing the effect of soil reaction on sugar beet stands, including the principles of soil liming, and on summarizing the effectiveness of composite humic-calcined soil preparations on soil pH change.
The efficacy of the composite preparations was tested in a polyfactorial ex-*situ* experiment, based on four soil types and using a remote range with dose variability. Three soil preparations were tested, 2 of which were humic-calcium and 1 was a soil conditioner based on humic acids. The calcium component of the composite preparations consists of chalk, the natural equivalent of limestone characterized by a high degree of purity and a calcium carbonate content of up to 90%. Humic acids, a natural stimulator of soil fertility, are an additive mixed in an amount of 10%, resp. 30%. The results of the experiment, which lasted 30 days under standard conditions, confirm the high effectiveness in changing the soil pH.

Key words: sugar beet, soil reaction, humino-calcium composite, soil preparation

Abstrakt

Predkladaná práca je zameraná na zhrnutie vplyvu pôdnej reakcie na porasty cukrovej repy vrátane zásad vápnenia pôdy a zároveň aj na zhrnutie účinnosti kompozitných humino-vápenatých pôdnych preparátov na zmenu pH pôdy.
Účinnosť kompozitných preparátov bola testovaná v polyfaktoriálnom ex-*situ* nádobovom pokuse, založenom na štyroch typoch/druhoch pôd a využitím odľahlého rozsahu pri variantnosti dávok. Testované boli 3 pôdne preparáty, z toho 2 humino-vápenaté a 1 preparát na báze humínových kyselín. Vápenatú zložku kompozitných preparátov tvorí krieda, prírodný ekvivalent vápenca vyznačujúci sa vysokým stupňom čistoty a až 90 % obsahom uhličitanu vápenatého. Humínové kyseliny, prírodný stimulátor úrodnosti pôdy sú prídavnou látkou zamiešanou v množstve 10%, resp. 30%. Výsledky pokusu, ktorý pri štandardných podmienkach trval 30 dní, potvrdzujú vysokú účinnosť humino-vápenatých preparátov na zmenu pôdnej reakcie.

Kľúčové slová: cukrová repa, pôdna reakcia, humino-vápenatý kompozit, pôdny preparát

Introduction

In relation to sugar beet, the soil acts as an environment ensuring the rooting of plants, the supply of water and minerals to its roots. Therefore, the soil and its fertility are one of the essential factors for obtaining good and high-quality sugar beet crops. An important indicator of soil fertility is the soil reaction, which affects the growth and development of cultivated crops, the activity of microorganisms in the soil and is of great importance in the soil-forming process. Soil acidity affects the mobility and accessibility of the most important plant nutrients, especially phosphorus and potassium. The adverse effect of the soil reaction is also associated with the mobility of aluminum and iron cations. Hardly soluble aluminum and iron phosphates are formed in acidic soils, in which phosphorus is practically inaccessible to plants (1). According to Hraško et al. (2) one of the causes of soil acidification is the leaching of basic cations. Ivanič, Havelka and Knop (3) found out plants tolerate the same degree of soil acidity better in a cation-rich soil solution compared to a cation-poor solution.

It is known that sugar beet requires a neutral to slightly alkaline soil reaction. The extreme range of soil reaction is wider but should not fall below pH 6.0 and exceed pH 7.5. At extreme values of soil reaction in sugar beet according to Vang et al. (4), there are ultrastructural and anatomical changes and, consequently, a significant reduction in the grown crop. The root system, the supply of nutrients and water to the plant is primarily affected, and the basic biochemical functions of the crop are disturbed.

Sugar beet is one of the crops under which liming is suitable, if the determined value of the soil reaction requires it. Liming should be done in autumn after harvesting the pre-crop, before organic fertilization, or with the pre-crop. For liming, it is advisable to use not only calcareous and dolomitic limestone, but also saturated sludge, which is a source of nutrients, or various soil additives containing calcium. Such soil auxiliaries, also certified for ecological soil management, include various preparations used to accelerate the decomposition of post-harvest residues, to regenerate the soil, to improve the soil structure and increase the utilization of available nutrient reserves in the soil. Balla et al. (5) noted an increase in soil reaction values ranging from 0.14 to 0.65 after the application of soil additives.

By liming the soil with saturation sludge in doses of 15 t/ha and 30 t/ha Antunović et al. (6) noted an increase in soil reaction from pH (in KCl) 4.2 to 5.8, or 7.3. At the same time, in the first year after soil liming, an increase in the corn yield was found from 3.97 t/ha (0 t/ha of saturated sludge) to 4.47 t/ha (15 t/ha), respectively, to 7.98 t/ha (30 t/ha). In the second year after liming with saturation sludge, an increase in the sugar beet yield from 39.6 t/ha (0 t/ha) to 49.2 t/ha (15 t/ha), or to 60.9 t/ha (30 t/ha). Higher sugar beet yields by an average of 4.97 t/ha after the application of saturating sludge in a dose of 10 t/ha and industrial fertilizers than on variants with only the use of industrial fertilizers were also recorded by Wilczewski et al. (7). The authors confirmed the fact that liming increases the efficiency of fertilizing with industrial fertilizers.

Čumakov (8) found that the highest sugar beet yields were obtained at an active pH above 7.2. A decrease in the soil reaction below the mentioned limit caused a decrease in the yield of sugar beet tubers. With the addition of calcium fertilizers, Fenn, Taylor and Burks (9) found a 26% increase in sugar beet tuber yield over the control without application of calcium fertilizers. In experiments on light sandy soil, Gutmański (10) observed the influence of liming, application of farmyard manure and the date of harvest on the effectiveness of nitrogen doses applied under sugar beet. The greatest impact on the yield and quality of sugar beet was the extension of the vegetation to 200 days, followed by manure and liming.

Calcium stimulates the translocation of assimilates from leaves to roots and accelerates sugar beet ripening. The direct result of the application of calcareous substances to the soil is the modification of the soil reaction (11), and the indirect result is the subsequent changes in other soil properties that correlate with the value of the soil reaction.
The task of liming is to achieve and maintain the optimal value of the soil reaction, so the object of liming is the soil. Calcium fertilizers are substances with an alkaline effect, which are supposed to cover the annual losses of calcium through its leaching from the soil, uptake by crops, the action of industrial fertilizers and the influence of wet atmospheric fallout, which according to Bízik et al. (12) are at the level of 350 kg/ha CaO. In order to prevent soil acidification, it is necessary to replenish the total calcium losses with the help of regular maintenance liming of the soil. Optimum value of soil reaction will be achieved by liming the soil using the annual norms of doses of calcium fertilizers in t/ha of CaO, which depend on the type of soil and soil reaction. The need for regular liming of the soil is also pointed out by Vigovskis et al. (13).
Calcium plays an important role not only in plant nutrition, but especially in the creation of soil fertility. It affects the accessibility of other macro and microelements in the soil, which is reflected in yields and quality parameters of production. Calcium neutralizes soil acidity and thus inhibits the uptake of heavy metals (14). After soil liming, soil properties change in the entire complex and more favorable conditions are created for the development of soil microflora.

Material and methods, ex-*situ* container experiment

In order to evaluate the influence/effectiveness of composite humus-calcium soil preparations on changing the pH/KCl soil reaction of differentiated soil species, we established a polyfactorial ex-*situ* container experiment in 2021.
The main parameter, exchange soil reaction - pH/KCl, was monitored according to methodological regulation ISO 2.11 (STN ISO 10390). The tested material was:

- 4 soil types, or soil matrix taken from the topsoil layer of typologically different parcels at VSN. The properties of the soil samples are listed in tables 1-3, soil type affiliation is determined based on the proportion of particles of category I (tables 1a,b).
- 3 soil preparations, 2 of which are composite humus-calcium and 1 original (control) preparation based on humic acids. The calcium component of composite preparations consists of chalk, sedimentary rock - a friable, porous and weakly consolidated equivalent of limestone, characterized by a high degree of purity with a calcium carbonate content of up to 90%. Humic acids, a natural stimulator of soil fertility, is an additive mixed in the amount of 10%, or 30%. It is a soil auxiliary substance obtained by treating leonardite, a more detailed description of the humic preparation used and its effect on sugar beet was given in a previous study (15).

From a methodological and legislative point of view, within the framework of effectiveness testing, it was necessary to solve variant dosing of preparations with an outlying range and at the same time for a targeted change of the soil reaction in the soil profile 0-20 cm, in accordance with the Act on the Protection and Use of Agricultural Land Act No. 220/2004 Coll. (16). The verified range, or doses of tested soil preparations in t/ha are part of the evaluation graphs (figures 3 to 5).

Table 1a: origin, sites and typology of soil samples

Site / typology	soil type	category by grain fraction
Vysoká nad Uhom	middle soil	loamy
Malý Horeš	light soil	sandy
Pozdišovce	heavy soil	clay-loamy
Oborín	middle soil	loamy

Table 1b: grain composition of the soil, content of fractions in %

Parameter / site	Vysoká nad Uhom	Malý Horeš	Pozdišovce	Oborín
1st fraction, <0.001 mm	17.15	3.67	23.14	20.92
2nd fraction, 0.001–0.01 mm	25.58	4.56	23.01	18.50
3rd fraction, 0.01–0.05 mm	37.93	8.79	39.00	44.37
4th fraction, 0.05–0.25 mm	18.52	67.66	13.18	15.20
5th fraction, 0.25–2.0 mm	0.82	15.32	1.67	1.01
content of particles of I. category	42.73	8.23	46.15	39.42

where: grain composition of the soil, classification of the soil type based on the percentage content of particles of the I. category (< 0.01 mm) according to Novák's classification scale, 1st fraction - clay, 2nd fraction – fine and medium dust, 3rd fraction – coarse dust, 4th fraction – fine sand, 5th fraction – medium sand

Table 2: agrochemical parameters

Parameter / site	Vysoká nad Uhom	Malý Horeš	Pozdišovce	Oborín
total nitrogen – N_t, %	0.197	0.082	0.168	0.184
available phosphorus – P, mg/kg	17.3	114.9	19.8	135.8
available kalium – K, mg/kg	149.8	463.8	313.8	299.2
available magnesium – Mg, mg/kg	371,5	82.0	284.1	277.5
available calcium – Ca, mg/kg	3106	929	2628	2541
exchangeable soil reaction – pH/KCl	6.22	5.36	4.67	5.45
soil organic carbon – C, %	1.59	0.77	1.32	1.55
humus, %	2.74	1.33	2.27	2.67

where: content of total nitrogen determined according to Kjeldahl (Hrivňáková and Makovníková et al. 2011), content of available nutrients (P, K, Mg, Ca) determined according to the Mehlich 3 method (Mehlich 1984), content of exchange soil reaction determined potentiometrically (ISO 10390 2005), soil organic carbon and humus determined by the Tjurin method (ISO 14235 1998)

Table 3: selected soil parameters before the treatment

Soil sample / parameter	moisture, %	temperature, °C	conductivity, mS/cm
Vysoká nad Uhom	6.8	24.5	0.015
Malý Horeš	4.2	25.0	0.004
Pozdišovce	3.5	24.0	0.009
Oborín	2.6	24.8	0.006

Table 4: identity and composition of the soil preparations

Preparations / composite compounds	chalk	humic preparation	pH / H_2O
Calcium Carbo Forte 10	90%	10%	8.4
Calcium Carbo Ultra 30	70%	30%	8.2
HUMAC Agro	0%	100%	7.5

Soil samples were taken on August 2, 2021, from the 0-20 cm soil profile. After collection, the samples were freely dried at room temperature of 20-25 °C for 7 days, after drying they were sifted through a sieve with holes of 2 x 2 mm, thereby being homogened at the same time. Before use, the granules of the tested preparations were crushed in a laboratory mortar, then they were sifted through a sieve with openings of 0.5 x 0.5 mm, thus homogened at the same time.
A polyfactorial ex-*situ* container experiment was

- established on August 12, 2021, and closed on September 11, 2021,
- composed of 3 factors (soil type - soil preparation - dose of soil preparation) and had 248 members, of which
    - o 240 treated members (4 soil types x 3 preparations x 10 treatments/doses x 2 repetitions),
    - o 8 untreated control members (4 soil types of species x 2 repetitions).

The treatment of the experimental members consisted in thoroughly mixing the weight of the soil sample with the weight of the preparation, while

- the weight of the soil sample for each experimental member was 87.0 g of dry soil,
- dosages of preparations (in the range of 0.021 - 1.500 g) were adequate to doses of 0.734 - 1.472 - 2.207 - 2.941 - 3.690 - 4.414 - 6.621 - 14.724 - 36.897 - 51.724 t/ha. Converted per kg of dry soil, these are doses of preparations in the range of 0.245 - 17.241 g/kg. Regarding the 90% content of calcium carbonate in the chalk and according to the preparation also to 10, respectively, the 30% content of the composite humic component refers to doses of CaO in the range of 0.333-23.471 t/ha for Calcium Carbo Forte 10 and 0.259-18.255 t/ha for Calcium Carbo Ultra 30.

Each test member was inserted by compression into a separate container with a volume of 96 cm^3, after insertion and re-compression, each test member was covered with water with a volume of 20 cm^3.
The experiment lasted 30 days, it was kept at a room temperature of 20-25 °C, -from which the first 21 days were in irrigation mode and the last 9 days were without irrigation. A total of 6 waterings were used with a total volume of water used of 50 cm^3 for each experimental member.

Results, the effectiveness of the composite preparations

As shown in the Synthetic graph (figure 6), the effectiveness of both tested composite humus-calcium preparations for changing the soil reaction after 30 days is high, while the mutual difference in the observed "quick effectiveness" is minimal to almost negligible.
When liming with carbonate forms of calcareous masses according to the doses and fineness of grinding, the effect of liming is the highest in the 2nd to 4th year, then gradually fades away. The "quick effectiveness" of calcareous substances is associated with the finest fraction, with a fraction of up to 1 mm in size, the highest effect of liming occurs after only 3-4 weeks after application.
The original formulation of the tested soil preparations are granules up to 8 mm in size, which in terms of the speed of onset of effectiveness on the soil reaction means a slower course. At the same time, it means a reduction in drift losses, from the point of view of application.
From the point of view of the composition of the tested composite humus-calcium preparations, the essential difference is in the amount of humic acids added, which are generally known for their beneficial effect on a range of chemical, physical and physico-chemical properties of the soil, as well as the support of microbial life in the soil. The beneficial effect of humic acids and calcium is mutually complementary or even synergistic, e.g., the beneficial effect of humic acids on the formation of waterproof structural soil aggregates is conditioned by Ca^{2+}. Conversely, humic acids increase the sorption capacity of the soil, which prevents the loss of CaO from the soil. Average annual losses of CaO, only as a result of leaching, amount to 160 kg/ha in Slovak conditions. Other specific losses of CaO are caused by industrial fertilizers (elimination of physiologically acidic fertilizers) and water atmospheric precipitation, representing roughly 70 kg/ha annually. Harvesting of crops alone represents an average of 30 kg/ha per year, i.e., the average intensity of maintenance liming in Slovakia is 260 kg/ha CaO. In the case of a one-time liming system for the sowing process, with an 8-year rotation, the need is 2.1 t/ha of CaO, or 3.7 t/ha CaCO3 (conversion coefficient 1.785).
With different emphasis, both tested composite soil preparations provide complementary improved properties of humic acids and calcium substances, while the impact on the soil reaction is high and they are suitable for soil reaction modification. The resulting graphs (figures 3 to 5) are designed in a way that makes it possible to determine the required dose of both preparations for a targeted change in the soil reaction in the soil profile 0-20 cm, according to soil types. Therefore, when dosing both tested preparations, we recommend proceeding in an unchanged form according to the calcium mass dosing system (CaO in t/ha), which is established by the cited Act on the Protection and Use of Agricultural Land, Act No. 220/2004 Coll., where in point 4. "Liming of agricultural land" of Annex no. 1 are listed "Doses of calcareous substances (CaO in t/ha) for arable land, fruit orchards, hop farms and vineyards to achieve the target pH in the 0-0.2 m layer" and "Doses of calcareous substances (CaO in

t/ha) for permanent grasslands to achieve the target pH in the 0-0.2 m layer". Doses specified in the tables cited it is possible/necessary to correct the law

- regarding the purity of the chalk itself, i.e., 10% increase (at 90% purity)
- regarding the content of the mixed partner, i.e., increase by another 10, or 30%.
- and by converting CaO to $CaCO_3$, i.e., conversion factor of 1.785.

The maximum dose of CaO is 1.5-3.0-5.0 t/ha per year, depending on the soil type on light-medium-heavy soil. Therefore, if the purity of the chalk is neglected, the need for liming is exceed~~s~~ed 2.9 - 5.9 - 9.8 t/ha with Calcium Carbo Forte 10, or 3.5 – 6.9 – 11.6 t/ha with Calcium Carbo Ultra 30, the remaining dose must be applied in the following year.

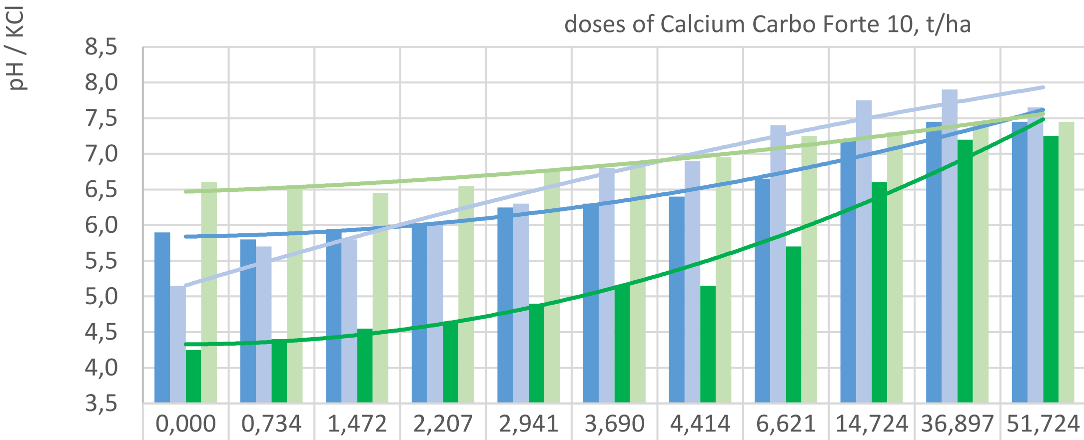
Table 5: overcalculation of recommended doses in t/ha for arable land, fruit orchards, hop farms and vineyards to achieve the target pH in the 0-0.2 m layer, with neglected chalk purity

soil pH/KCl /	Calcium Carbo Forte 10			Calcium Carbo Ultra 30		
preparation / soil type	light	middle	heavy	light	middle	heavy
4.0-4.1	5.9	12.2	15.1	7.0	14.4	17.9
4.2-4.3	5.3	11.2	14.1	6.3	13.2	16.7
4.4-4.5	4.7	10.2	13.0	5.6	12.1	15.3
4.6-4.7	4.1	9.2	12.0	4.9	10.9	14.2
4.8-4.9	3.5	8.2	10.8	4.2	9.7	12.8
5.0-5.1	2.9	7.3	9.8	3.5	8.6	11.6
5.2-5.3	2.4	6.3	8.6	2.8	7.4	10.2
5.4-5.5	1.8	5.3	7.7	2.1	6.3	9.0
5.6-5.7	1.2	4.3	6.5	1.4	5.1	7.7
5.8-5.9	0.6	3.3	5.5	0.7	3.9	6.5
6.0-6.1		2.4	4.3		2.8	5.1
6.2-6.3		1.4	3.3		1.6	3.9
6.4-6.5		0.4	2.2		0.5	2.6
6.6-6.7			1.2			1.4
6.8-6.9						
7.0<						

References:

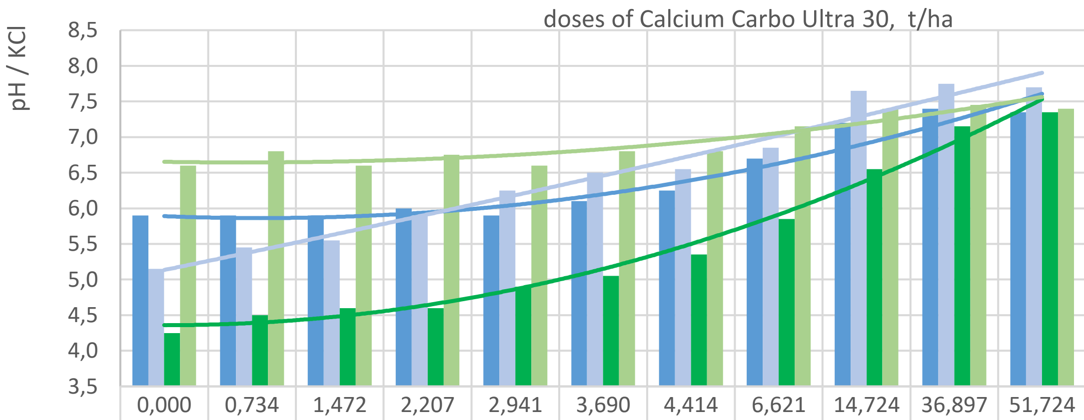
1. Repka, J.; JuránIová, l. 1978: Agrochemická účinnosť fosforečných hnojív. Agrochémia, 18, 1978 (1), p. 9–12.
2. Hraško, J. et al. 1984: Pôda v poľnohospodárskej výrobe. Bratislava: VÚRV, 1984, 141 pp.
3. IvanIč, J.; Havelka, B.; Knop, K. 1984: Výživa a hnojenie rastlín. Bratislava: Príroda, 1984, 432 pp.
4. WanG, G. et al. 2022: Growth status and physiological changes of sugar beet seedlings in response to acidic pH environments. Journal of Plant Physiology, DOI 10.1016/j.jplph.2022.153771.
5. Balla, P. et al. 2012: Effect of soil utilization modes on the mater circulation in Gleyic Fluvisol. In Examination of the effect of land utilization systems on water and nutrient circulation of soil. Debrecen, 2012, p. 66–84, ISBN 978-963-473-594-6.
6. Antunović, M. et al. 2002: Vliv vápnění saturačními kaly na výnos cukrovky a kukuřice. Listy cukrov. řepař., 118, 2002 (9–10), p. 214–216.

7. Wilczewski, E.; Szczepanek, M.; Wenda-Piesik, A. 2018: Response of sugar beet to humic substances and foliar fertilization with potassiumReakcja buraka cukrowego na substancje humusowe i dolistne nawożenie potasem. Journal of Central European Agriculture, 19, 2018 (1), p. 153–165, DOI: /10.5513/JCEA01/19.1.2033
8. Čumakov, A. 1989: Pestujeme cukrovú repu správne? Úroda, 37, 1989 (5), s. 218–220.
9. Fenn, l. B.; Taylor, R. M.; Burks, C. M. 1991: Calcium stimulation of ammo nia absorption in beets. Amer. Soc. Agron. Annu. Meet., 1991, p. 286–287.
10. Gutmański, I. 1990: Dzielanie wapna, obornika i terminu zbioru na efek tyw nošč dawek azota stosowanych pod buraki cukrowe. Biuletyn instytutu Hodowli i aklimatyzacji rošlin, 1990 (176), p. 58–82.
11. Capuani, S. et al. 2015: Combination between Acidity Amendments and Sewage Sludge with Phosphorus on Soil Chemical Characteristics and on Development of Castor Bean. Communications in soil science and plant analysis, 22, 2015 (22), p. 2901–2912.
12. Bizík, J. et al. 1998: Metodika hnojenia a výživy rastlín. 1. vyd. Bratislava: AT Publishing Bratislava, 1998, 112 pp., ISBN 80-967812-1-9.
13. Vigovskis, J. et al. 2016: The changes of soil acidity in long-term fertilizer experiments. Zemdirbyste-Agriculture, 103, 2016 (2), p. 129–134.
14. Sobocká, J. et al. 2005: Klimatická zmena a jej možné dopady na pôdny fond Slovenska. 1. vyd. Bratislava: VÚPOP, 2005, 46 pp.
15. Tóth, Š. et al. 2016: Wpływ Humacu Agro na plon, zawartość cukru w burakach cukrowych i właściwości gleby w warunkach zrów noważonego systemu rozwoju rolnictwa. Annales Universitatis Mariae Curie-Skłodowska. Sectio E. Agricultura, 71, 2016 (1), p. 77-86.
16. Zákon č. 220/2004 Z. z.: Zákon o ochrane a využívaní poľno hospodárskej pôdy a o zmene zákona č. 245/2003 Z. z. o integrovanej prevencii a kontrole znečisťovania životného prostredia a o zmene a doplnení niektorých zákonov.
17. HrIvňáková, K. et al. 2011: A uniform workflows analysis of soils. Brati slava: Soil Science and Conservation Research Institute, 2011, 136 pp., ISBN 978-80-89128-89-1.
18. Mehlich, A. 1984: Mehlich 3 soil test extractant: A modification of Meh lich 2 extractant. Commun. Soil Sci. Plant Anal., 15, 1984, p. 1409–1416.
19. ISO 10390 2005. Soil quality – Determination of pH. IOS, Ge neva. 7 pp.
20. ISO 14235 1998. Soil quality – Determination of organic carbon by sulfochromic oxidation. IOS, Geneva. 5 pp.
21. Tóth, Š. et al. 2013: Význam a efekt pôdnych zlepšovačov rôzneho typu pri ich použití v podmienkach diferencovanej intenzity obrá bania pôd. 1. vyd. Michalovce: Centrum výskumu rastlinnej vý roby (Pieš ťany, Slovensko), 2013, 112 pp., ISBN 978-80-89417-46-9.



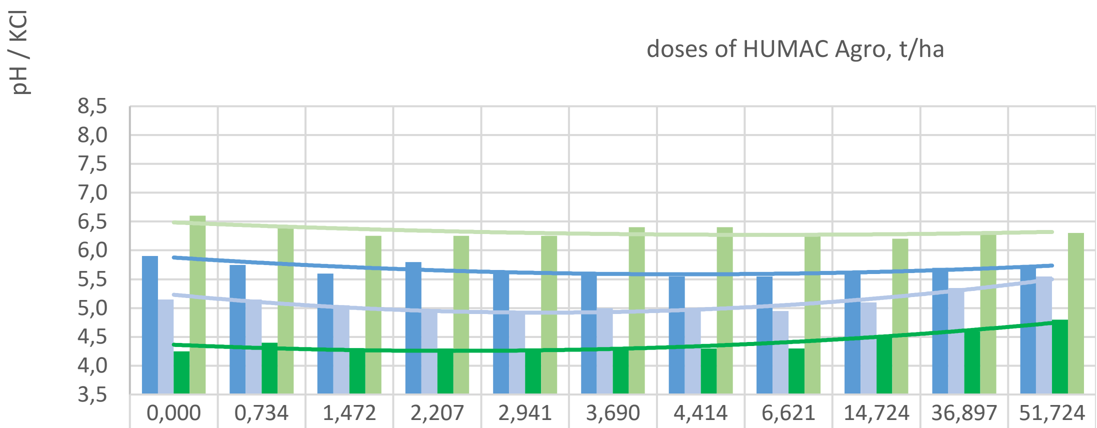
	0,000	0,734	1,472	2,207	2,941	3,690	4,414	6,621	14,724	36,897	51,724
Oborín	5,9	5,8	6,0	6,0	6,3	6,3	6,4	6,7	7,2	7,5	7,5
Malý Horeš	5,2	5,7	5,8	6,0	6,3	6,8	6,9	7,4	7,8	7,9	7,7
Pozdišovce	4,3	4,4	4,6	4,7	4,9	5,2	5,2	5,7	6,6	7,2	7,3
Vysoká nad Uhom	6,6	6,5	6,5	6,6	6,8	6,9	7,0	7,3	7,3	7,4	7,5

Figure 1: the effect of the dose of Calcium Carbo Forte 10 on the change in soil pH of different soil samples (Oborín - Malý Horeš - Pozdišovce - Vysoka nad Uhom) after 30 days of application



	0,000	0,734	1,472	2,207	2,941	3,690	4,414	6,621	14,724	36,897	51,724
Oborín	5,9	5,9	5,9	6,0	5,9	6,1	6,3	6,7	7,2	7,4	7,4
Malý Horeš	5,2	5,5	5,6	5,9	6,3	6,5	6,6	6,9	7,7	7,8	7,7
Pozdišovce	4,3	4,5	4,6	4,6	4,9	5,1	5,4	5,9	6,6	7,2	7,4
Vysoká nad Uhom	6,6	6,8	6,6	6,8	6,6	6,8	6,8	7,2	7,4	7,5	7,4

Figure 2: the effect of the dose of Calcium Carbo Ultra 30 on the change in soil pH of different soil samples (Oborín - Malý Horeš - Pozdišovce - Vysoka nad Uhom) after 30 days of application



	0,000	0,734	1,472	2,207	2,941	3,690	4,414	6,621	14,724	36,897	51,724
Oborín	5,9	5,8	5,6	5,8	5,7	5,6	5,6	5,6	5,6	5,7	5,8
Malý Horeš	5,2	5,2	5,1	5,0	5,0	5,0	5,0	5,0	5,1	5,4	5,6
Pozdišovce	4,3	4,4	4,3	4,3	4,3	4,3	4,3	4,3	4,5	4,6	4,8
Vysoká nad Uhom	6,6	6,4	6,3	6,3	6,3	6,4	6,4	6,3	6,2	6,3	6,3

Figure 3: the effect of the HUMAC Agro preparation dose on the change in soil pH of different soil samples (Oborín - Malý Horeš - Pozdišovce - Vysoka nad Uhom locations) after 30 days of application

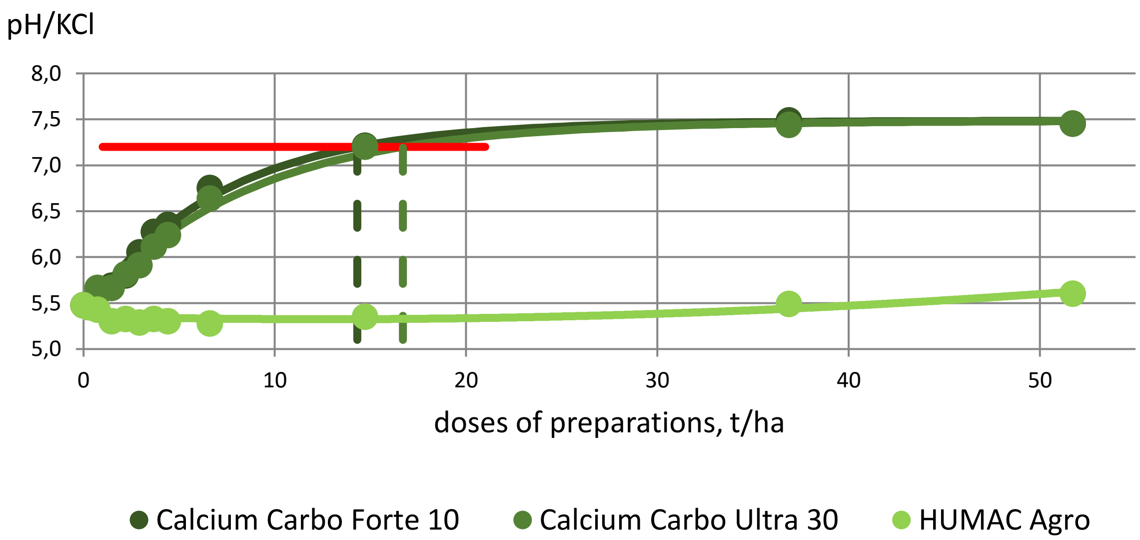


Figure 6: the effect of the dose of the preparations Calcium Carbo Forte 10, Calcium Carbo Ultra 30 and HUMAC Agro on the change in the soil reaction after 30 days from the application of the preparations

Figure 1a: sandy soil, Malý Horeš

Figure 1b: clay-loamy soil, Pozdišovce

Figure 1c: loamy soil, Oborín

Figure 1d: loamy soil, Vysoká nad Uhom

Figure 2a: humus-calcium composite Calcium Carbo Forte 10 in the used fraction

Figure 2b: humus-calcium composite Calcium Carbo Ultra 30 in the used fraction

Figure 2c: humic preparation HUMAC Agro in the used fraction

Figure 7: pH meter HI 22 10

Figure 8: soil liming, soil pH is important when growing sugar beet