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# THE INFLUENCE OF LIMING ON THE CONTENT OF SOME MICROELEMENTS IN PLANTS

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A b s t r a c t. Liming, irrespective of lime dose, had no marked influence on the amount of oats yield, while the yield of beets tops and roots increased parallel with the dose of lime calculated for 1 Hh. As the result of liming, Cu concentration in oats tops decreased along with an increase in lime dose to 1 Hh level, whilst in beets leaves the level of copper increased under the same conditions. Zn and Mn concentrations in tops and roots of both plants decreased along with a raise in calcium fertilizer dose. Liming had no greater effect on Fe level in oats tops, but it decreased this element content in beets leaves. The effect of liming was slightly dependent on lime dose, the species and part of a plant, and on the time which elapsed since the application of calcium fertilizer.

K e y w o r d s: liming, microelements in plants, oats, fodder beets

## INTRODUCTION

There are numerous papers dealing with the influence of changes in soil reaction, as a result of liming, on microelements uptake by plants and their chemical composition [6,9,11, 15,17,18]. In the areas polluted by industry, liming may be one of the factors which diminish the uptake of heavy metals [13]. There have been many studies on the content of Cu in soil and plants depending on soil reaction. However, the results obtained are diversified. Only a slight relation, or even none regularities between soil pH and copper amount in plants have been stated in some papers [5,7-9], while in other [11] liming was said to oniy irregularly influence copper solubility in soil. Copper concentration in plants with its natural content in soil and lower doses of CuSO4 did not change systematically under liming influence. With the application of high CuSO4 doses liming clearly decreased the content of copper in oats tops and roots, and Cu amount was dependent on $CaCO_3$ dose. In many papers soil reaction has been explicitly stated to decide about Zn, Mn and Fe availability in soil and also about the level of these elements in plants [1,2,12,14]. There has been noticed a marked decrease in the content of zinc forms most easily available to plants (water soluble Zn and exchangeable Zn) with an increase in soil pH, which limits this element uptake by plants [1]. Liming with dolomite clearly affected a decrease in Mn and Fe content in 0-20 cm arable topsoil [14]. In soils with natural content of trace elements and in industry polluted soils they are incorporated in food chain and it is difficult to set the limit of their deficiency or toxic amount of these elements from the point of view of nutritive and fodder requirements [16,17]. Thus, liming may limit not only the level of these elements in fodder, but also their toxicity. In case of fodder with their low con- centration it may increase the deficiency of these components [13,16].

## METHODS

Changes in concentrations and uptake of some microlements caused by liming were studied during a three year long pot experiment carried out in 1989-1991 on oats of Dragon cv. and fodder beets of Cyklop cv. Soil with granulometrical composition of silty clay and very acid reaction ($pH_{H_2O}$ 4.86; $pH_{KCl}$ =3.96; Hh=7.14 cmol $kg^{-1}$) was used in the experiment. The soil (5 kg of air dried soil per pot) was limed with $CaCO_3$ six weeks before the plants sowing in the following doses: 0, 0.25, 0.5, 1 and 2 of soil hydrolytic acidity (Hh). Basic fertilization with chemically pure salts was applied each year a few days before sowing, per pot with:

| | | |
|---|---|---|
| 0.4 g N | as | $NH_4NO_3$; |
| 0.3 g $P_2O_5$ | | $Ca(H_2PO_4)_2$; |
| 0.5 g $K_2O$ | | KCl |
| 0.1 g Mg | | $MgSO_4 \cdot 7 H_2O$ |

The experiment was carried out in four replications. The plants were sown by the end of April, oats were harvested at their full earing phase, fodder beets were gathered each year in the middle of July. Plants were watered with re-distilled water, soil moisture was initially maintained on the level of 40 % and then at 60 % of maximum soil water capacity. After their harvesting, the plants were dried in the temperature of 105 °C, weighed and ground. Cu, Zn, Mn and Fe were assayed with AAS method in the plant material prepared as above, after its dry mineralization. Soil samples were collected each year after plants harvesting and pH assayed in 1 mol KCl $dcm^{-3}$ solution.

## RESULTS

Liming, irrespective of its $CaCO_3$ dose, had no marked influence on the amount of oats tops yield. Yields of beets tops and roots increased to the dose of lime calculated for 1 Hh, and its further raise had no visible influence on the yield of beets tops and roots (Table 1). An average weighted concentration of Cu for three years decreased from 4.65 to 3.71 mg $kg^{-1}$ of d.m. of oats tops and went on decreasing along with an increase in lime dose to 1 Hh level. Further increase in $CaCO_3$ dose slightly raised the content of this element. The amount of lime dose did not visibly affect copper concentration in oats roots, and a weighted average of this element ranged from 7.85 to 5.76 mg $kg^{-1}$. Opposite dependencies for the influence of liming on copper content have been noted between oats and beets, which is a result of differences between species. Beets tops and roots responded with an increase in copper content up to lime dose corresponding to 1 Hh, and a decline in this element concentration when the lime dose was higher (Fig. 1). A weighted average content of this element in beets leaves rose from 16.7 on the control to 20.3 mg $kg^{-1}$ on the object limed with lime dose corresponding to 1 Hh, while in roots it was respectively 11.0 and 14.1 mg $kg^{-1}$ of d.m. In the second year after liming a decrease occurred in copper content in beets leaves together with $CaCO_3$ dose, which may be explained by a considerable increase in yield and a result of diluting.

Accumulation of Zn, Mn and Fe in tops and roots of both plants was clearly dependent on lime dose, kind and part of a plant. Concentration of zinc, manganese and iron in beets leaves and roots was much higher that in respective parts of oats. A decline in zinc and manganese concentrations in both species was parallel to an increase in lime dose. An average weighted of zinc content in oats tops on the control was 80.9 and was lowering to 34.6 mg $kg^{-1}$ on the object limed according to 2 Hh. In roots it lowered from 216.2 to 49.2 mg $kg^{-1}$ of d.m. (Fig. 2). An average weighted of manganese content in oats tops was decreasing from 458.2 to 67.2 mg $kg^{-1}$ and in roots from 396.2 to 114.2 mg $kg^{-1}$ of d.m. (Fig. 3). Beets response to liming was more significant than oats. An average content of zinc in beets leaves on the control was 809.0 and lowered to 63.9 mg $kg^{-1}$ on the object limed according to 2 Hh, and from 215.7 to 47.4 mg $kg^{-1}$ in roots (Fig. 2). The level of manganese in beets leaves decreased markedly along with an increase in $CaCO_3$ dose and, as compared to the

**Table 1.** Yields of above-ground parts and roots (g/pot) and $pH_{KCl}$ of soil after vegetation

| $CaCO_3$ dose acc. Hh | Oats | | | Beets | | |
|---|---|---|---|---|---|---|
| | above-ground parts | roots | pH | above-ground parts | roots | pH |
| | | | 1989 | | | |
| 0 | 20.28 | 3.07 | 3.9 | 1.47 | 0.20 | 3.9 |
| 0.25 | 20.40 | 2.45 | 4.2 | 7.57 | 0.90 | 4.1 |
| 0.5 | 20.30 | 2.12 | 4.9 | 11.05 | 1.77 | 4.7 |
| 1.0 | 21.08 | 2.32 | 6.0 | 11.72 | 2.30 | 5.9 |
| 2.0 | 21.23 | 1.85 | 6.7 | 11.05 | 1.75 | 6.7 |
| LSD(p=0.05) | 0.96 | 0.23 | | 1.00 | 0.21 | |
| | | | 1990 | | | |
| 0 | 20.87 | 4.78 | 3.9 | 4.30 | 0.71 | 3.5 |
| 0.25 | 22.87 | 4.83 | 4.2 | 10.73 | 2.51 | 4.0 |
| 0.5 | 24.10 | 4.88 | 4.7 | 16.80 | 9.48 | 4.5 |
| 1.0 | 24.40 | 4.93 | 5.8 | 17.80 | 8.79 | 5.7 |
| 2.0 | 21.70 | 4.30 | 6.6 | 18.30 | 8.48 | 6.5 |
| LSD(p=0.05) | 1.01 | 1.03 | | 1.25 | 1.47 | |
| | | | 1991 | | | |
| 0 | 29.85 | 4.52 | 3.7 | 2.32 | 0.41 | 3.6 |
| 0.25 | 27.70 | 4.03 | 4.1 | 12.29 | 3.10 | 3.9 |
| 0.5 | 29.57 | 4.47 | 4.4 | 12.13 | 3.81 | 4.1 |
| 1.0 | 29.46 | 4.06 | 5.6 | 13.51 | 5.62 | 5.3 |
| 2.0 | 30.59 | 3.91 | 6.7 | 14.24 | 4.26 | 6.7 |
| LSD(p=0.05) | 1.62 | 0.35 | | 0.97 | 0.44 | |
| | | | Mean from 1989 - 91 | | | |
| 0 | 23.67 | 4.12 | 3.8 | 2.70 | 0.44 | 3.7 |
| 0.25 | 23.44 | 3.77 | 4.2 | 10.20 | 2.17 | 4.0 |
| 0.5 | 24.66 | 3.82 | 4.7 | 13.33 | 5.02 | 4.4 |
| 1.0 | 24.98 | 3.77 | 5.8 | 14.34 | 5.57 | 5.6 |
| 2.0 | 24.51 | 3.35 | 6.7 | 14.53 | 4.83 | 6.6 |
| LSD(p=0.05) | 1.19 | 0.54 | | 1.07 | 0.71 | |

control in the object limed according to 1 Hh it was 33 times lower (4613 and 138 mg $kg^{-1}$ of d.m., respectively), in case of roots it was 12 times lower (755.8 and 62.7 mg $kg^{-1}$ of d.m., respectively) (Fig. 3). In the following years the content of zinc and manganese in leaves and roots of both plants rose on the control and on the object treated with the lowest $CaCO_3$ dose, as a result of repeated soil acidification.

Liming had no greater influence on iron level in oats tops, but it lowered this element level from 1593 to 950 mg $kg^{-1}$ of d.m. in roots (Fig. 4). In beets liming lowered the accumulation of this component in leaves from 229 on the control to 152 mg $kg^{-1}$ of d.m. on the object treated with the highest $CaCO_3$ dose. Concentration of iron decreased respectively from 135 to 98 mg $kg^{-1}$ of d.m. in roots.

Zn, Mn and Fe uptake by the tops and roots of both plants decreased more or less visibly and depended on lime dose. Copper

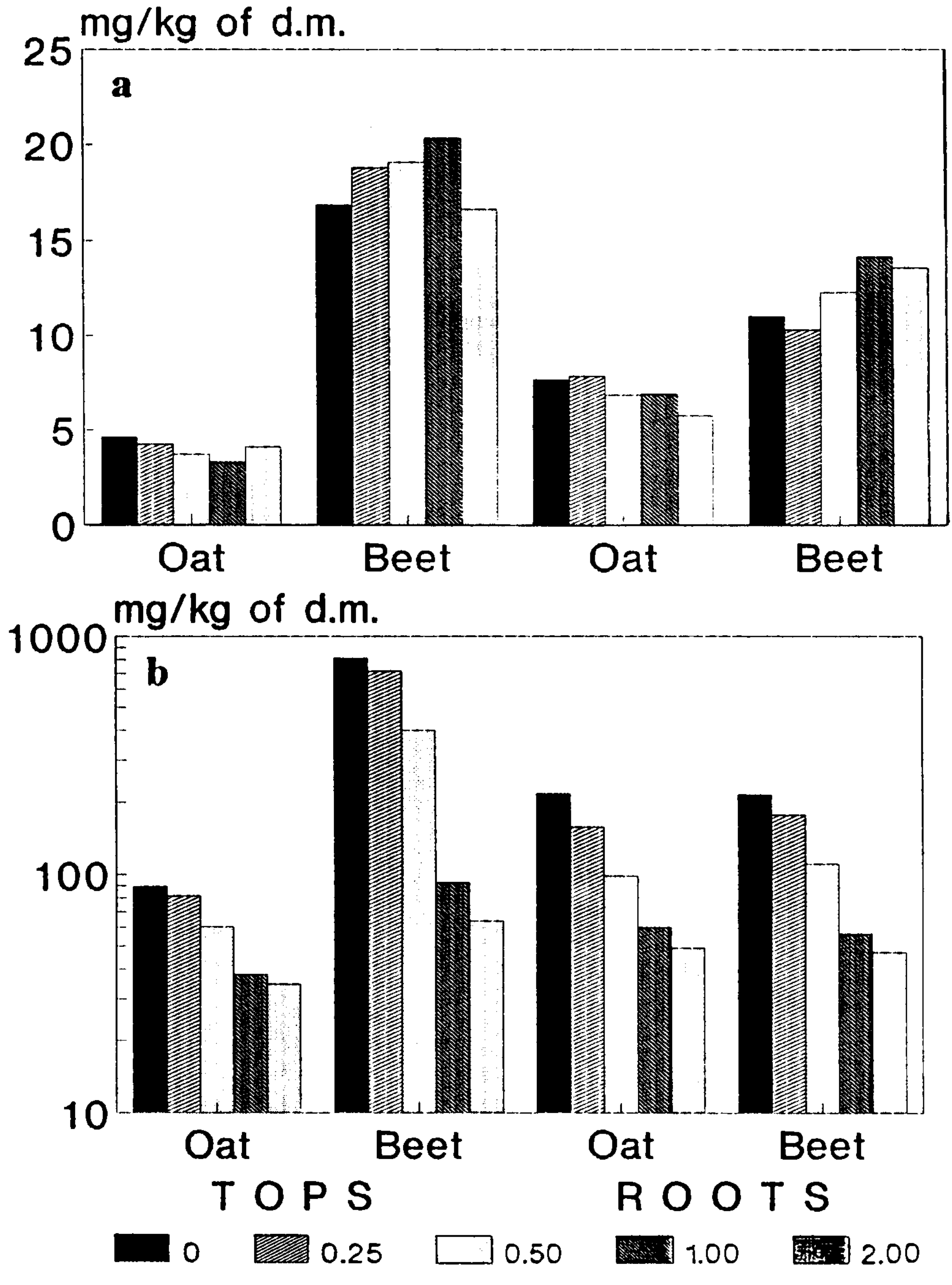


Fig. 1. Microelements content in plants: a) copper, b) zinc, c) manganese, d) iron.

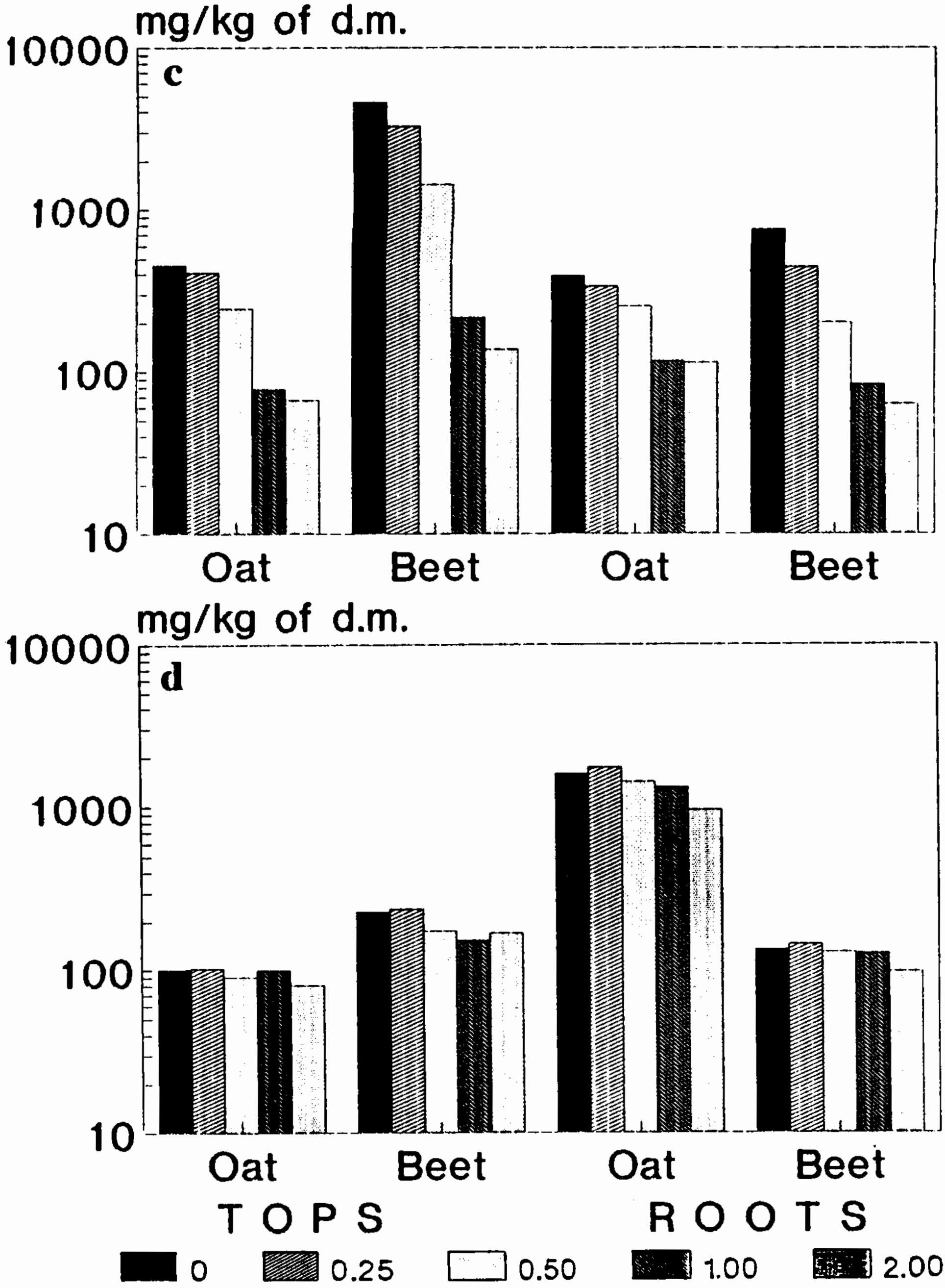


Fig. 1. Continuation.

uptake by oats was lowering along with $CaCO_3$ dose, while in beets its uptake by both leaves and roots increased.

## DISCUSSION

Liming and various $CaCO_3$ doses influence the yielding and chemical composition of plants in different ways. It is a result of different responses of particular plant species to changes in soil reaction [3,5,15]. In the presented experiment, differences in Cu, Zn, Mn and Fe content occurred irrespective of lime dose, kind and part of plants, and the time which elapsed since the application of liming (the year of investigations). Data quoted in literature [4,9] confirm different reactions of plants to copper content resulting from changes in soil reaction. Together with pH increase Cu content decreased only in sunflower and radish tops. Such influence on this element concentration in maize and ryegrass has not been confirmed. The obtained results are compatible with the data presented in literature which point out that liming and $CaCO_3$ dose decrease copper concentration in oats tops [11]. The content of this component increased in tops and leaves of beets together with the raise in applied $CaCO_3$ dose up to the dose calculated according to 1 Hh. Changes in soil reaction caused by liming slightly decreased the content of copper in oats roots and irregularly influenced the level of this component in beets roots.

A lowering of zinc concentration in oats tops was 2.5 times and in roots 5 times in object treated with a double dose of $CaCO_3$ as compared with the control. A decline of zinc level in beets leaves was more apparent. The content of zinc in beets leaves decreased 12 times, when we compare the object with a double lime dose and the control, and 5 times in case of roots. Similar results were achieved by other authors who showed that pH influence on phytoavailability of the metal rose together with its increasing concentration in soil [4,6].

The content of manganese was decreasing parallel with lime dose. An average weighted content of this component in oats tops lowered 7.5 times and in roots 3.5 times in object treated with a double dose of $CaCO_3$ as compared with the control. Manganese accumulation in beets leaves on the unlimed object was 10 times higher then in oats tops. An average content of manganese in beets leaves lowered 33 times and in roots 12 times as a result of liming. A significant influence of liming on accumulation and uptake of manganese by plants has been confirmed by many authors [2,18]. CaO application caused threefold decrease in manganese content on mineral meadows, while its amount in the hay from peat soils decreased only by 26 %. Magnesium lime decreased the amount of manganese by 40 % [18].

Irrespective of lime dose, liming insignificantly affected iron content in oats tops, while a decrease in the level of this element was noticeable in roots. In beets leaves and roots liming influenced iron concentration parallel to the lime dose but less noticeably than in case of other components. Similar results were achieved by other authors [18]. CaO application on mineral meadows caused a decline in iron content by 25 % and twofold decrease in its concentration on organic soils. In such conditions the applied magnesium lime raised iron content in hay from peat meadows. The influence of different forms of nitrogen on iron content has been noted by other authors [10]. The lowest concentration of this element was discovered in oats and sorrel with the application of calcium nitrate. The authors suppose it to be indirect influence, through this form of fertilizer, upon soil reaction.

The effect of liming is much dependent on lime dose, plant species and time which elapsed since the application of this treatment, so in order to achieve a positive effect, it is essential to choose the dose of lime which would ensure pH optimal for plants yielding.

## CONCLUSIONS

1. Liming influenced oats yield only to some extent, but with an increase in lime dose it markedly raised the yield of beets.

2. A decrease in Cu, Zn and Mn content in tops and roots of oats, as well as a decline in

Zn and Mn concentrations in beets leaves and roots occurred parallel to an increasing dose of lime.

3. Copper content in beets leaves and roots was raising along with the applied amount of $CaCO_3$ up to its dose calculated for 1 Hh.

4. The content of Cu, Zn, Mn and Fe in plants depended on lime dose, species and part of plant and the year of the experiment.

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## WPŁYW WAPNOWANIA NA ZAWARTOŚĆ NIEKTÓRYCH MIKROELEMENTÓW W ROŚLINACH


Wapnowanie niezależnie od dawki wapna nie miało większego wpływu na wielkość plonu owsa, natomiast plony części nadziemnych i korzeni buraków wzrastały równolegle do dawki wapna obliczonej według 1 Hh. W efekcie zwapnowania gleby koncentracja Cu w częściach nadziemnych owsa obniżała się ze wzrostem dawki wapna do poziomu 1 Hh, natomiast w liściach buraków w tych samych warunkach poziom miedzi wzrastał. Koncentracja Zn i Mn w częściach nadziemnych i korzeniach obu roślin obniżała się ze wzrostem dawki nawozu wapniowego. Wapnowanie nie miało większego wpływu na poziom Fe w częściach nadziemnych owsa, natomiast obniżało zawartość tego pierwiastka w liściach buraków. Efekt wapnowania zależał w dużym stopniu od dawki wapna, gatunku i części rośliny oraz czasu jaki upłynął od zastosowania nawozu wapniowego.


S ł o w a  k l u c z o w e: wapnowanie, mikroelementy w roślinach, owies, buraki pastewne.