EFFECT OF LIMING ON THE YIELD AND SOME NUTRIENT ELEMENT CONTENT OF MAIZE (*ZEA MAYS L.*)

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Abstract:

The even higher acidity of our soils is a well-known phenomenon, whether it is partly a consequence of natural processes, or rather of anthropogenic activities. It can significantly limit the quality and amount of crop-yield. Therefore beside the efficient nutrient-supply we have to ensure the adequate soil pH in maize (*Zea mays L.*) production. Whereas changed soil pH can modify the availability of nutrients from the soil and so the nutrient supply of plants as well.

Based on a new soil acidity determination method a new technology has been developed for the amelioration of acid soils. According to this technology the amount of liming material is equal to the amount of H^+ in the liquid and solid phase and the H^+ deriving from protolityc reactions. The Hungarian liming recommendation system – that is based on the hydrolytic acidity – gives twice as high lime doses than the new method.

In our research work the yield and element composition of plants grown on limed and not limed soils was compared. We have chosen 3 sites with acidic and extremely acidic soil for our field experiment. We used pressed lime sludge, that has low moisture content, as liming material.

These experiments confirm the results of former experiments that the lime amount calculated from the hydrolytic acidity is excessive. This investigation proved that this lime amount decreases the maize yield and element content compared to the half dose of the calculated lime amount. These experiments showed that the present Hungarian liming recommendation system results lime overdose that is unnecessary and partly harmful.

Introduction:

In Hungary the problem of natural and/or anthropogenic acidification of the soils has a great importance because the area that is susceptible for acidification covers more than the half of

the country's land. The knowledge of the exact value of soil acidity is important because of lime requirement estimation, thus their amelioration and protection of soils (Várallyay et al., 1980; Várallyay, 2006; Husti, 2006).

In Hungary and in some other countries the $CaCO_3$ amount needed to ameliorate acid soils is calculated by the consideration their hydrolytic acidity (HAC_1). In the measurement suggested by Kappen (1929) the acidity of the equilibrium solution of the soil's calcium acetate extract is quantified. This acidity value shows only the equilibrium value of H_3O^+ amount corresponding to the given soil/extractant ratio (active soil acidity). To determine the total releasable surface acidity (potential soil acidity) the soil must be continuously percolated or the soil/extractant ratio must be changed (Filep, 1999).

For the elimination of this principle error of Kappen's method the soil acidity can be determined by the pH-stat titration of the soil suspension (Czinkota et al., 2002).

Based on the new soil acidity determination method a new technology has been developed for the amelioration of acidic soils. According to this technology the amount of liming material is equal to the amount of H^+ in the liquid and solid phase and the H^+ deriving from protolityc reactions. The Hungarian liming recommendation system, that is based on the hydrolytic acidity, gives twice as high lime doses than the new method.

In this work the yield and element composition of plants grown on limed and not limed soils will be compared.

Materials and methods:

For the experiment 3 sites with low soil pH were chosen from the farms of KITE ZRt. The soil properties of these sites are shown in Table 1. The experiments had 3 treatments in 4 replications in a randomised plot design. The area of each plot was 0.1 ha. The treatments were the calculated full and the half lime dose. The lime dose was calculated by the following formula: lime dose $=0.0174*K_A*HAC_1$ ($t.ha^{-1}$). Where K_A is the upper limit of plasticity and HAC_1 is the hydrolytic acidity determined by Kappen (1929). The liming material was lime sludge from the sugar industry with 80% $CaCO_3$ content. We set up our experiments during 2006 and 2007. For the results of the plant analysis in this paper we took plant samples on 27th June 2006. Determination of plant element concentrations was carried out with ICP-AES method after cc. HNO_3 + H_2O_2 wet digestion in the laboratory of RISSAC. At harvest the grain yield and moisture content of maize were measured. The yield values were converted to the value of May (14% moisture content). For data evaluation 2 and 3 factor analysis of variance were used.

Table 1. Some properties of soil samples

Site	Álmosd 1.	Álmosd 2.	Vasmegyer
K_A*	29.9	30.7	38.7
HAC_1	14.77	16.43	28.59
pH-KCl	4.52	4.46	3.63
pH-$CaCl_2$	4.56	4.49	3.71
Bulk density kg/dm^3	1.38	1.39	0.87
Full lime dose t/ha	7.68	8.78	19.25

* upper limit of plasticity

Results and discussion:

The yield of the two years of the experiment (counted to the value of May: 14% moisture content) was evaluated in function of the site, lime dose and year with 3 factor ANOVA (Table 2).

Table 2. Maize grain yield calculated to the value of May in function of year, site and liming treatment (t ha^{-1}).

Year	2006			2007		
Site	Control	Half dose	Full dose	Control	Half dose	Full dose
Vasmegyer	8.92	9.16	7.84	7.12	7.67	7.23
Álmosd 1	9.01	8.70	8.11	7.96	7.98	8.01
Álmosd 2	8.21	8.01	7.59	8.57	8.66	8.59
Average	8.71	8.62	7.85	7.88	8.10	7.94
$LSD_{5\%}$	0.54					

The average of half dose treatments in 2006 showed no significant change compared to the control but the full dose caused yield depression. In the second year (2007) one year after liming these effects were not that significant. The yield increment in the half dose and full dose treatment was not significant compared to the control. The full dose treatment caused yield decrease compared to control and half dose treatment in the average of years and sites too. The average values of yield of the different treatments were the following: control 8.3, half dose 8.36 and full dose 7.9 $t.ha^{-1}$. The $LSD_{5\%}$ for these values was 0.38. The average of the yield on the three sites was not significantly different. The yield in 2007 was significantly smaller than in 2006. This decrease was in accordance with the changes of nationwide yield thus it is caused by the weather.

Some nutrient element concentrations of plant samples in the first year of the experiment were compared in function of production site and liming treatments. The Ca content of the

plants were influenced by both site and liming technology. In all treatments the maize in Vasmegyer contained less Ca than the plant samples of the two Álmosd sites. The average values showed the same trends (Table 3).

Table 3. Ca content in maize (above ground parts together) in function of liming treatments and site (%)

Site	Control	Half dose	Full dose	Average
Vasmegyer	3.980	4.694	4.692	4.455
Álmosd 1	5.662	6.150	6.693	6.168
Álmosd 2	5.502	6.510	5.977	5.997
Average	5.048	5.785	5.787	
$LSD_{5\%}$	0.550			0.952

Table 3 shows that the half dose liming increased the Ca content of maize compared to that of the control but the full dose did not have any further effect on it.

Only the site influenced significantly the K content of maize. In the average of the treatments the K content at Vasmegyer was 3.1% while on Álmosd 1 site 1.8% and on Álmosd 2 site 1.5%. The $LSD_{5\%}$ value was 0.5% thus K content on the two Álmosd sites were the same but on the Vasmegyer site it was twofold higher. The average value of the treatments for the control treatment was 2.4% for half dose 2.1% and for full dose 2.0%. The $LSD_{5\%}$ value for these data was also 0.5% thus the decrease in K content of the plants caused by liming was not significant.

The P and S content of the plant samples were equalized. Nor the site neither the liming treatment had any significant influence on maize P and S content (Table 4 and 5).

Table 4. P content in maize (above ground parts together) in function of liming treatments and site (%).

Site	Control	Half dose	Full dose	Average
Vasmegyer	3.281	3.293	3.177	3.250
Álmosd 1	3.113	3.305	3.139	3.186
Álmosd 2	3.281	3.293	3.177	3.250
Average	3.225	3.297	3.165	
$LSD_{5\%}$	0.241			0.241

Table 5. S content in maize (above ground parts together) in function of liming treatments and site (%).

Site	Control	Half dose	Full dose	Average
Vasmegyer	1.683	1.766	1.633	1.694
Álmosd 1	1.684	1.766	1.729	1.726
Álmosd 2	1.622	1.737	1.592	1.650
Average	1.663	1.757	1.651	
$LSD_{5\%}$	0.222			0.222

The Cu content of maize was significantly different on the different sites. In the average of the treatments the Cu content in Vasmegyer was 6.4 in Álmosd 1 7.9 and in Álmosd 2 8.1 $mg.kg^{-1}$. The $LSD_{5\%}$ is 0.7 thus there was no difference between the two Álmosd sites but on Vasmegyer the Cu content of maize was significantly lower. This phenomenon can be the consequence of the high organic matter content of the Vasmegyer soil. The average values of the treatments were 7.0 $mg.kg^{-1}$ for control, 7.8 $mg.kg^{-1}$ for half dose and 7.5 $mg.kg^{-1}$ for full dose. The $LSD_{5\%}$ value (0.7) showed that the Cu content of the plants increased significantly even in the half dose lime treatment. The decrease of the Cu content in the full dose treatment was not significant.

Table 6. Fe content in maize (above ground parts together) in function of liming treatments and site ($mg.kg^{-1}$).

Site	Control	Half dose	Full dose	Average
Vasmegyer	133	175	156	155
Álmosd 1	160	150	156	156
Álmosd 2	144	160	176	160
Average	146	162	162	
$LSD_{5\%}$	11			11

The Fe content of the plants did not change in function of sites (Table 6). The Fe content increased significantly only in the half dose treatments according to the average of the sites. The application of full dose did not cause further Fe content increment of maize. On the Vasmegyer soil the full dose liming decreased the Fe content of maize compared to the half dose treatment ($LSD_{5\%}$ = 19 $mg.kg^{-1}$).

Conclusions

These experiments confirm the results of former experiments that the lime amount calculated from the hydrolytic acidity is excessive. This investigation proved that this lime amount decreases the maize yield and element content compared to the half dose of the calculated lime amount. These experiments showed that the present Hungarian liming recommendation system results lime overdose that is unnecessary and partly harmful.

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