FIELD TESTING OF NEW, MORE EFFICIENT LIMING METHOD.

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Abstract:

Based on the 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 this work the yield and element composition of plants grown on limed and unlimed soils will be compared. 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.

Keywords: acidic soil, liming, maize, acidity titrated, hydrolytic acidity

Introduction

The soil's basic functions may suffer a loss by natural or anthropogenic acidification. In Hungary this problem has a great importance because the area 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 considering their hydrolytic acidity (HAC_1). In the measurement suggested by Kappen (1929) the acidity of the equilibrium solution of the soil's Ca-acetate extract is quantified. This acidity value shows only the equilibrium value of H^+ amount corresponding to the given soil/extractant ratio. To determine the total releasable surface 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 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.

Csatho (2001) found that lime doses according to the recommendation system are adequate to loamy clay and clay soils but on sand and sandy loam 50% of the full lime dose was the most efficient.

In this work the yield and element composition of plants grown on limed and unlimed soils will be compared.

Materials and methods

For the experiment 3 sites with low soil pH were chosen from the farms of KITE Rt. The soil properties of these sites can be seen in Table 1. The experiments had 3 treatments in 4 replications in randomised plot design. The area of one 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 $=17.4*K_A*HAC_1/1000$ ($t.ha^{-1}$). Where K_A is the upper limit of plasticity and HAC_1 is the hydrolytic acidity. The liming material was sugar industry sludge with 80% $CaCO_3$ content. The applied plant was maize in both years (2006, 2007). The plant samples were taken on 27th June 2006. Determination of plant element concentrations was carried out with ICP-AES method after cc. HNO_3 + H_2O_2 digestion in the laboratory of RISSAC. At harvest the grain yield of maize and moisture were measured. The yield values were converted to the value of May (14% moisture content). For data evaluation 2 and 3 factor ANOVA was 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

Foremost the 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 every treatment the maize in Vasmegyer contained less Ca than the plant samples of the two Álmosd site. The average values showed the same trends (Table 2).

Table 2. Ca 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	3980	4694	4692	4455
Álmosd 1	5662	6150	6693	6168
Álmosd 2	5502	6510	5977	5997
Average	5048	5785	5787	
$LSD_{5\%}$	550			952

Table 2 shows that half dose liming heightened the Ca content of maize compared to that of the control but the full dose did not increased it further.

Only the site significantly influenced the K content of the maize. In the average of the treatments the K content in Vasmegyer was 3.1% while on Álmosd 1 site 1.8% and on Álmosd 2 1.5%. The $LSD_{5\%}$ value was 0.5% thus K content on the Álmosd sites are 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 3 and 4).

Table 3. P 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	3281	3293	3177	3250
Álmosd 1	3113	3305	3139	3186
Álmosd 2	3281	3293	3177	3250
Average	3225	3297	3165	
$LSD_{5\%}$	241			241

Table 4. S 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	1683	1766	1633	1694
Álmosd 1	1684	1766	1729	1726
Álmosd 2	1622	1737	1592	1650
Average	1663	1757	1651	
$LSD_{5\%}$	222			222

The Cu content of the 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 smaller. 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 Cu content decrease in the full dose treatment was not significant.

The Fe content of the plants did not change in function of sites (Table 5). 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 increment is the maize. On the Vasmegyer soil the full dose liming decreased the Fe content of the maize compared to the half dose treatment ($LSD_{5\%}$ = 19 $mg.kg^{-1}$).

Table 5. 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 yield of the two years of the experiment (counted in the value of May: 14% moisture content) was evaluated in function of the site, lime dose and year with 3 factor ANOVA (Table 6).

Table 6. 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 treatment in the year 2006 showed not significant change compared to the control but the full dose caused yield depression. In the second year (2007) one year after liming the effects are 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 for 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 different significantly. 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.

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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