THE LONG-TERM EFFECTS OF LIMING ON THE DRY MATTER PRODUCTION AND CHEMICAL COMPOSITION OF PERENNIAL RYEGRASS (*LOLIUM PERENNE L.*)

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Abstract:

For studying the long-term effect of meliorative liming, a field experiment was set up in four replications, at three production sites, during the year 2006. Besides the control combinations (not treated with lime), a lime-dose calculated upon the Hungarian Liming Recommendation System (that is based on the hydrolytic acidity) and the half of this dose resp. were added to the treatment combinations. A year later, soil samples were taken from each sites and plots, and a pot-experiment on the basis of Mitscherlich was set up, with perennial ryegrass (*Lolium perenne L.*) as a test plant. In this work the yield and element composition of plants grown on limed and not limed soils will be compared. These experiments confirm the results of former experiments that state, that the lime amount calculated from the hydrolytic acidity is excessive.

Keywords: acidic soil, hydrolytic acidity, liming, perennial ryegrass, pot experiment

Introduction

Soil acidity as a consequence of anthropogenic loadings and natural processes has a negative influence on soil parameters. This problem became more and more serious with the intensive fertilizer-application through the years, and more than the half of Hungarian soils are affected by it. The knowledge of the exact value of soil acidity is important for the estimation of lime requirement, thus the amelioration and protection of soils (Várallyay, 2006; Husti, 2006). In Hungary, just like in many other countries of the world, the $CaCO_3$ amount needed to ameliorate acid soils is calculated by considering their hydrolytic acidity (HAC_1). In this measurement the acidity of the equilibrium solution of the soil's Ca-acetate extract is quantified (Kappen, 1929). The other parameter, that is currently used to define the lime-requirement of soils is the soil plasticity index (K_A) according to Arany (Filep, 1999), which refers to the amount of organic and inorganic colloids in the soil, as well. However, many experiments suggest, that the lime-requirement calculated upon this method is not always appropriate (Zsuposné, 2005). Liming can significantly modify the organic and inorganic nitrogen-content of sandy soils (Filep et al., 2002). Changes in soil pH can influence the availability of nutrients, and through this the yield of plants (Kádár, 2007). The long-term effect of liming can be different on soils with different characteristics (Kátai, 2006, Prokisch et al., 2007). To reveal the long-term effect of liming, we set up field and (on their basis) pot experiments as well. . In this work the dry matter production and Ca-, P-, K-, S-, Cu- and Fe-content of ryegrass grown in pot experiments on – with and without lime treated – soil samples from the previous year field experiment will be compared.

Materials and methods

For the basic field-experiment 3 sites with low or even extreme low soil pH value were chosen from the north eastern part of Hungary. The most important soil properties of these sites are presented in Table 1. The experiments had 3 treatments in 4 replications in randomised plot design. The area of each plot was 0.1 ha. The treatments were the determined full and the half lime demand. 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. The liming material was sugar industry sludge with 80 % of $CaCO_3$ content. The plots were treated during the spring of 2006. Exactly a year after we set up the field-experiment, we took soil samples from all layers of each parcel, so that we could use them in the pot-experiment. In the pot-experiment we used Mitscherlich-pots. We added 2.5 kg air dry state soil and 40 mg kg^{-1} N (in form of NH_4NO_3-solution) per each pot. Perennial ryegrass (*Lolium perenne L.*) was used as test plant. The above ground biomass was cut after 28 days, then the dry matter production per pot was weighed. The 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. For data evaluation 2 and 3 factor ANOVA was used.

Table 1. Some properties of the soils of experiment sites

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 soil plasticity

Results and discussion

The fresh matter production per pot depended close significantly on the soil site and on the added amount of liming material as well. Regarding, that the interaction between liming and soil site was also significant, it has to be considered, that liming had a different effect on different soils.

Table 2. The fresh and dry matter production of perennial ryegrass, g pot^{-1}

Year	Fresh matter				Dry matter			
Site	Control	Half dose	Full dose	Average	Control	Half dose	Full dose	Average
Álmosd 1	9.6	7.8	5.8	7.7	1.8	1.8	1.3	1.6
Álmosd 2	23.0	11.2	6.0	13.4	3.6	2.1	1.5	2.4
Vasmegyer	23.2	27.2	31.8	27.4	4.9	5.2	6.1	5.4
Average	18.6	15.4	14.5	16.2	3.4	3.0	3.0	3.1
F_{site} = 486*** F_{lime} = 27*** $F_{interaction}$ = 590***					F_{site} = 909*** F_{lime} = 22** $F_{interaction}$ = 65***			

From the data of Table 2 it can be stated, that at soil site Álmosd 1 half dose of liming material did not have any effect, while lime dose calculated to the Hungarian Liming Recommendation System had a depressive effect on the yield. Similar tendencies were observed in case of soil site Álmosd

2, but at this site the half dose of liming material has already had a yield-reducing effect. The tendencies were different at Vasmegyer soil site, which is characterized by the extremely high acidity. At this site treatments with lime increased yield, especially the higher lime dose resulted in yield increment.

Ca content of plants (Table 3) was primarily determined by soil site makings, still the positive effect of liming was also dominant. At all three soil sites it can be stated, that half dose of liming material increased the Ca content of plants intensely. In comparison to this, the full dose did not have a more expressed effect. K content of plants also depends mostly on soil site, but liming had a significant effect, as well: at both sites of Álmosd 1 and 2 the K uptake decreased according to liming. This can be explained by the antagonism between ions.

Table 3. Ca and K content in the above ground dry matter of ryegrass in function of liming treatments and site ($mg.kg^{-1}$)

Year	Ca				K			
Site	Control	Half dose	Full dose	Average	Control	Half dose	Full dose	Average
Álmosd 1	22213	24602	24027	23614	32300	26879	25814	28331
Álmosd 2	14398	20094	21136	18543	39850	32203	27681	33244
Vasmegyer	8494	10588	9902	9662	34830	38262	35595	36229
Average	15035	18428	18355	17273	35660	32448	29697	32601
F_{site} = 470*** F_{lime} = 24*** $F_{interaction}$ = 4*					F_{site} = 99*** F_{lime} = 28*** $F_{interaction}$ = 14***			

Regarding the P uptake of plants it can be stated – similar to K uptake – that plants grown at soil site Vasmegyer contained P in the highest concentration. The availability of P was decreased by adding the smaller amount of liming material, while full dose resulted in the destruction of P supplement of plants at each soil sites (Table 4).

Table 4. P and S content in the above ground dry matter of ryegrass in function of liming treatments and site ($mg.kg^{-1}$)

Year	P				S			
Site	Control	Half dose	Full dose	Average	Control	Half dose	Full dose	Average
Álmosd 1	2822	1931	1755	2169	3075	3007	3114	3065
Álmosd 2	3414	2617	1519	2517	3316	3257	3196	3256
Vasmegyer	4245	4504	3518	4089	2618	3091	2736	2815
Average	3494	3017	2264	2925	3003	3118	3015	3045
F_{site} = 437*** F_{lime} = 67*** $F_{interaction}$ = 18***					F_{site} = 42*** F_{lime} = 2ns $F_{interaction}$ = 4*			

S content of plants was not determined by the applied amount of liming material, the difference between the treatments was not significant according to this. Soil sites had an influence on the S uptake of plants.

In this paper we can only introduce the results – concerning the microelement content of plants – of copper and iron (Table 5). From the data of the table it can be stated that liming had no effect on the uptake of these elements, but their concentration in plants was determined by the soil site.

Table 5. Cu and Fe content in the above ground dry matter of ryegrass in function of liming treatments and site ($mg.kg^{-1}$)

Year	Cu				Fe			
Site	Control	Half dose	Full dose	Average	Control	Half dose	Full dose	Average
Álmosd 1	11.4	10.7	10.7	10.9	1247.3	1081.6	1258.4	1195.8
Álmosd 2	12.6	12.0	10.6	11.7	712.4	612.9	589.2	638.2
Vasmegyer	4.3	5.4	4.8	4.8	215.2	261.7	172.5	216.5
Average	9.4	9.4	8.7	9.2	725.0	652.1	673.4	683.5
F_{site} = 531*** F_{lime} = 3ns $F_{interaction}$ = 5**					F_{site} = 10** F_{lime} = <1ns $F_{interaction}$ = <1ns			

Conclusions

The results of our pot experiments confirm, that applying a dose of lime requirement, calculated upon the hydrolytic acidity and the soil plasticity, can have different results in different soil sites. The calculation estimates the lime requirement at soils with moderate acidity and low plasticity much higher, than needed. Adding this amount of liming material at these soil sites can result in the depression of the yield and disorders in the nutrient uptake. Our experiments also confirm the results of Csathó (2001).

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