IMPACTS OF LIMING WITH DOLOMITE ON SOIL PH AND PHOSPHORUS AND POTASSIUM AVAILABILITIES

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Abstract: Four stationary liming field experiments have been started in the period from 2003 to 2006 on the acid soils in Central Croatia. Dolomite meal containing 56% CaO and 40% MgO was applied in the amounts of 0, 5, 10 and 15 t ha^{-1} (the experiments I and II); 0, 6, 12, 18 and 24 t ha^{-1} (the experiment III) and 0, 10, 20, 30 and 40 t ha^{-1} (the experiment IV). All experiments were conducted in a randomized block design in four replicates. Liming with dolomite considerably affected soil pH and plant available phosphorus status, while differences of humus contents and plant available potassium were non-significant. Initial soil pH values (pH in 1M KCl) were 4.20, 3.74, 4.60 and 5.16 for the experiments I, II, III and IV, respectively. The highest rate of dolomite increased soil pH to the level of 6.87, 6.36, 7.00 and 7.32, respectively. Initial plant available phosphorus status in the soil of the experiment I was very low (below 5.0 mg P_2O_5 100 g^{-1}), in the soil of the experiment III extremely high (above 50 mg P_2O_5 100 g^{-1}), while in the remaining two experiments these values were in moderate availabilities (between 15 and 20 mg P_2O_5 100 g^{-1}). As affected by liming plant available phosphorus were increased for 45%, 33%, 8% and 32%, for the experiments I, II, III, and IV, respectively.

Keywords: liming, dolomite, soil pH, phosphorus and potassium availability

Introduction

Soil acidity is a global problem in food production for the increasingly growing human population. Acid soils are widespread in Croatia and they cover 831.704 ha, representing about 32% of total agricultural land (Mesić et al., 2009). Soil acidification is a permanent natural process that is present in most soils used for plant production. If proper measures for the correction of excessive soil acidity were not applied, those soils would eventually become more acidic. Improving the acid soils fertility through the application of different liming materials is a widely recognized practice to enhance crops productivity (Mesic, 2001; Rengel, 2003). However, at the same pH value different soils response differently to the same amount of lime material and positive responses may not be achieved immediately. The solubility and nutrients availability is strongly dependent on soil pH. One of the most evident consequences of low soil pH in Croatia is insufficient level of available phosphorus. Numerous studies showed the positive effect of liming on phosphorus availability, as well as on grain crops yield. The objective of this study was to evaluate the effect of liming with dolomite on soil pH as well as on plant available phosphorus and potassium.

Material and methods

Four stationary field experiments of liming with dolomite meal containing 56% CaO and 40% MgO were started in the period from 2003 to 2006 on the acid soils of Pozega-Slavonian County (the experiments I–III) and Bjelovar-Bilogora County (the experiment IV). The experiments were conducted in four replicates. In the first year of the experiments as well as in the following years, standard fertilization of the experiment was performed. The annual crops were rotated in the I-III experiments,

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while alfalfa was grown in the experiment IV. Soil sampling (0-30 cm depth) was done in October of 2004 after maize harvesting at the end of the second year for the experiments I and II; in August of 2009 during the third year for the experiment III and in July of 2005 after the first cutting of alfalfa (the experiment IV). Soil pH was determined according to ISO (1994), humus content by sulfocromic oxidation (ISO, 1998) and plant available phosphorus and potassium by ammonium-lactate extraction (Egner et al., 1960). Data were statistically analyzed by ANOVA and t-test procedure.

The experiment I

Dolomite was distributed in the spring of 2003 on the soil with pH in KCl 4.20 in Badljevina. In total four treatments were used as follows: control (without dolomite), 5, 10 and 15 t ha^{-1}. The size of basic plot was 92.4 m^2. The data regarding the experiment was in detail elaborated in the previous studies (Kovacevic et al., 2010; Rastija et al., 2010).

The experiment II

This experiment was identically arranged as the experiment I. These two experiments are distanced about 2 km. The soil of the experiment II was more acid (pH in KCl 3.74). More information about the experiment was published in the previous studies (Iljkic et al., 2011, 2013; Kovacevic and Rastija, 2010a).

The experiment III

The experiment III started in the autumn of 2006 close to the plot of the experiment II (about 0.5 km air-distance). Dolomite was applied in the amounts as follows: the control (without liming), 6, 12, 18 and 24 t ha^{-1}. The soil pH was 4.60. The experiment was arranged by the randomized block design in four replicates. Basic plot measured 49.5m^2 (Rastija et al., 2010b).

The experiment IV

The experiment IV started in the autumn of 2004 on Pavlovci acid soil (pH in KCl 5.16). Five treatments of dolomite were applied (0, 10, 20, 30 and 40 t ha^{-1}). The experiment was arranged by randomized block design in four replicates and basis plot measured 20.0 m^2. Some results of the experiment IV were shown in the previous studies (Popovic et al., 2007; Rastija et al., 2012).

Results and discussion

Liming with dolomite considerably affected soil chemical properties and raised pH value in all four experiments. Also, available phosphorus content was considerably improved by liming, while differences in humus contents and plant available potassium were non-significant.

In the experiments I and II dolomite application gradually raised pH from initially very low pH on the control to the adequate value near neutral, two years after liming. The highest rate increased pH value for 2.67 and 2.62 pH units (Table 1). In the experiment I even the lowest dolomite amount (5 t ha^{-1}) significantly increased pH. Soil in the second experiment is very acid (3.74) and only the highest dolomite rate improve pH. Despite such low pH, plant available phosphorus was in the range of moderate supply. However, statistically significant increase was achieved at the amounts of 10 and 15 t ha^{-1}, where P_2O_5 raised for 5.65 mg 100 g^{-1}. On the other hand, soil in the first experiment was extremely poor with phosphorus (4.80 mg 100 g^{-1}), and although phosphorus availability rose due to liming, its level still remained very low (Table 1).

Table 1. Liming effects on the soil chemical properties two years after dolomite application (the experiments I and II)*

The experiment I					The experiment II				
Lime	pH	%	mg 100 g^{-1}		Lime	pH	%	mg 100 g^{-1}	
t ha^{-1}		Humus	P_2O_5	K_2O	t ha^{-1}		Humus	P_2O_5	K_2O
0	4.20	2.05	4.80	10.20	0	3.74	2.75	17.18	21.65
5	6.08	2.14	4.80	9.30	5	4.90	2.67	17.73	21.80
10	6.22	2.02	7.15	10.50	10	5.71	2.88	21.20	23.20
15	6.87	1.96	6.98	10.20	15	6.36	2.78	22.83	23.15
$LSD_{0,05}$	0.29	ns	1.30	ns	$LSD_{0,05}$	0.37	ns	2.99	ns

*Kovacevic et al., 2010; Rastija et al., 2010; Kovacevic and Rastija 2010

As in the previous two experiments, in the experiment III pH also was gradually raised with increased liming. Three years after application at the highest dolomite rate (24 t ha^{-1}) pH value was increased by 2.4 pH units. In soil samples from this experiment a very high phosphorus availability was determined according to AL-method, because of previous rich phosphorus ameliorative fertilization. However, significant increase of phosphorus content was observed at higher dolomite rates. At the 18 t ha^{-1} of dolomite P_2O_5 increased for even 8.3 mg 100 g^{-1} compared to control (Table 2).

Table 2. Liming effects on the soil chemical properties (the experiments III and IV)

The experiment III					The experiment IV				
Lime	pH	%	mg 100 g^{-1}		Lime	pH	%	mg 100 g^{-1}	
t ha^{-1}		Humus	P_2O_5	K_2O	t ha^{-1}		Humus	P_2O_5	K_2O
0	4.60	1.90	50.43	19.77	0	5.16	2.18	19.1	22.6
6	5.58	1.98	52.50	21.53	10	6.75	2.17	23.2	21.9
12	6.76	2.05	54.50	20.97	20	6.94	2.00	23.5	20.6
18	6.74	2.24	58.77	22.57	30	7.23	2.12	25.1	22.2
24	7.00	2.40	54.50	22.20	40	7.32	2.00	25.3	22.3
$LSD_{0,05}$	0.27	0.21	4.39	ns	$LSD_{0,05}$	0.25	ns	1.6	ns

It is generally known that liming and soil acidity neutralizing increase phosphorus availability, but too high lime amounts can lead to its reducing (Rahman et al., 2002). In the experiment IV soil pH increased to even slightly alkaline reaction at the highest rate, but that didn't affect the phosphorus availability as phosphorus content was also the highest (Table 2).

Improvement of soil fertility by correction of soil pH through liming resulted in yield increases of the field crops, as the previous studies showed. In the experiment I maize responded to yield increases for 22% (2003), and 9% (2006), while yields of wheat and winter barley were increased for 33% (2007) and 10% (2005), respectively (Kovacevic et al., 2010; Rastija et al., 2010). In the experiment II maize yield increases were 15% (2003), 25% (2004), 134% (2005) and 50% (2007), while winter barley responded by 20% (2006) yield increase (Kovacevic and Rastija, 2010). Winter wheat (Iljkic et al., 2011) and oats (Iljkic et al., 2013) yield increases were up to 18% (2010) and 16% (2011). In the experiment III maize grain yield were increased by 10%. Popovic et al.

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(2007) reported about response of alfalfa to liming (the experiment IV) when hay yields significantly increased only in the second year of testing.

Conclusions

Liming with dolomite considerably affected soil chemical properties and raised soil pH from initially acid or very acid to neutral or slightly alkaline reaction. Improvement of soil acidity resulted in great increases of plant available phosphorus determined by AL-method. Application of the highest dolomite rates raised the phosphorus availability by 8% in the soils rich in phosphorus to 45% in the soils very poor in available phosphorus. Potassium availability was independent of liming. In future, soil monitoring regarding soil chemical properties of this stationary experiments is recommended, as liming have the residual effect.

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