Liming impact on soil chemical properties

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Abstract

In order to examine the residual effect of liming on soil pH and plant available phosphorus and potassium, soil samples from two field trials were analyzed. First trial was conducted in 2000 on Pleternica site where increasing rates of carbocalk (refuse from sugar factory with total Ca content 344 g kg⁻¹) was applied (0, 15, 30, 45, 60 and 90 t ha⁻¹), while soil samples were taken four years after liming. The second trial with 0, 6, 12, 18 and 24 t ha⁻¹ of dolomite containing 56% CaO and 40% MgO was set up at Badljevina locality in 2006 and soil sampling was done in 2009. Liming considerably affected the soil pH in the both trials. Carbocalk gradually raised soil pH from initial very acid to the slightly alkaline reaction, while dolomite application affected pH only at higher rates. Liming increased soil available phosphorus content for 12.1 mg 100 g⁻¹ four year after carbocalk application and for 8.3 mg 100 g⁻¹ three years after liming with dolomite. Liming with carbocalk significantly decreased potassium availability at 45 t ha⁻¹ and following higher rates, whilst dolomite didn’t affected potassium content.

Key words: liming, carbocalk, dolomite, soil pH, plant available phosphorus and potassium

Introduction

Acid soils with a pH lower than 5.5 are widespread in Croatia and cover an area up to 50 % of arable land (Kovacevic et al., 1993). Soil acidity adversely affects a number of soil chemical properties, such as accessibility of macro and micronutrients, as solubility of soil chemical compounds is related to soil pH. In such conditions, despite the standard mineral fertilization, there is a lack of expected fertilization effects on the growth and development of agricultural crops. Liming is general recommendation for acid soil improvement. There are plenty of liming materials which can be used for neutralizing acidity in surface soil, but the most common are calcium carbonate or ground limestone, dolomite, hydrated lime and carbocalk (waste of sugar beet factory). The impact of liming material on the soil pH alteration depends on amount as well as form of used material (Mesić, 2001.) Lončarić et al. (2006.) have shown the positive influence of carbocalk application on soil acidity decrease.

The low fertility of acid soils in Croatia is mostly due to inadequate level of available phosphorus (Kovacevic and Banaj, 2004, Kovacevic et al., 2005). One of the most emphasized consequences of soil acidity are disorders related to phosphorus nutrition (Gaume et al.,2001.). It is generally known that liming increase the availability of phosphorus and soil alkaline cations and reduces the availability of most heavy metals. Zhang et al. (2004) and Rahman et al. (2002) elaborated influence of liming on phosphorus availability in acid soils, stressing that a moderate pH increase leads to greater phosphorus availability, while too high doses can lead to its decreasing. The objective of this research was to determine the effect of liming with carbocalk and dolomite on soil pH as well as on plant available phosphorus and potassium.
Material and methods

The field trial with increasing rates of carbocalk (refuse from sugar beet factory with total Ca content 344 g kg\(^{-1}\)) was conducted in the autumn of 2000 on arable land of Kutjevo Agricultural Holding (Pleternica, Pozega-Slavonian County). Carbocalk was applied at following rates: 0, 15, 30, 45, 60 and 90 t ha\(^{-1}\). The size of experimental plot was 64.3 m\(^2\).


The second liming experiment was started in the autumn, 2006 at Badljevina locality, Pozega-Slavonia County. Dolomite meal containing 56% CaO and 40% MgO was applied as 0, 6, 12, 18 and 24 t ha\(^{-1}\). Basic plot measured 49.5 m\(^2\). Crop sequence was as follows: maize (2007) – wheat (2008) – maize (2009). The both trials were conducted in a randomized block design in four replicates.

Soil samples were taken in the summer of 2004 and 2009 for the first (Pleternica), and second (Badljevina) experiment, respectively. Soil pH (H\(_2\)O and M KCl,) 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.

Results and discussion

Carbocalk application considerably affected the soil pH and plant available P and K status in surface soil layer in the fourth year after application. Effect of liming was statistically proved at all treatments (Table 1). Soil pH (KCl) gradually raised from initial very acid reaction of 3.89 (control) to the slightly alkaline reaction (7.30) at the highest liming rate. Rate of 45 t ha\(^{-1}\) increased pH value near to neutral reaction pH (KCl) 6.62. Antunović et al. (2002) have found the increasing of soil pH (KCl) from 4.2 to 5.8 by using of 15 t ha\(^{-1}\) carbocalk. The humus content was similar at all treatments, except on the highest carbocalk rate where significant decrease was recorded.

Table 1 Influence of liming with carbocalk on soil properties 4 years after application (Pleternica, 2004)

<table>
<thead>
<tr>
<th>Carbocalk t ha(^{-1})</th>
<th>H(_2)O pH</th>
<th>KCl pH</th>
<th>Humus %</th>
<th>AL-P(_2)O(_5) mg 100 g(^{-1})</th>
<th>AL-K(_2)O mg 100 g(^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5.33 e</td>
<td>3.89 f</td>
<td>1.98 a</td>
<td>22.44 e</td>
<td>29.54 a</td>
</tr>
<tr>
<td>15</td>
<td>5.81 d</td>
<td>4.71 e</td>
<td>1.83 a</td>
<td>23.48 de</td>
<td>25.28 b</td>
</tr>
<tr>
<td>30</td>
<td>6.52 c</td>
<td>5.80 d</td>
<td>1.93 a</td>
<td>25.24 cd</td>
<td>23.55 bc</td>
</tr>
<tr>
<td>45</td>
<td>7.12 b</td>
<td>6.62 c</td>
<td>1.98 a</td>
<td>27.80 c</td>
<td>22.36 bc</td>
</tr>
<tr>
<td>60</td>
<td>7.35 b</td>
<td>6.95 b</td>
<td>1.92 a</td>
<td>30.68 b</td>
<td>22.31 cd</td>
</tr>
<tr>
<td>90</td>
<td>7.72 a</td>
<td>7.30 a</td>
<td>1.67 b</td>
<td>34.55 a</td>
<td>20.58 d</td>
</tr>
<tr>
<td>LSD(_{0.05})</td>
<td>0.25</td>
<td>0.32</td>
<td>0.18</td>
<td>2.70</td>
<td>2.51</td>
</tr>
</tbody>
</table>

Values followed by the same letter within each column are not significantly different at the 5% level

Significant increase of plant available phosphorus was achieved by the application of 30 t ha\(^{-1}\) carbocalk and its level raised correspondingly with pH. The highest phosphorus availability was determined at the highest carbocalk rate, although slightly alkaline soil reaction appeared. In the opposite, potassium availability significantly decreased at 45 t ha\(^{-1}\) and higher rates. Similar effect concerning AL-soluble phosphorus and potassium were noted by Zsigrai and Ori (2006) six years after liming. Rastija et al. (2008) have reported that application of 10 t ha\(^{-1}\) carbocalk raised pH value for 1.2 pH units in the first year and also
significantly increased phosphorus availability, but in the second year differences between control and liming were less pronounced, implying that effect of lower liming rates are short term.

Significant influence of soil surface liming with dolomite were recorded for all soil properties, except for potassium content (Table 2). Like in the first trial, pH was raised with increasing liming rates, but that was statistically confirmed only at higher dolomite treatment. The highest dolomite treatment (24 t ha⁻¹) increased pH value for 2.4 pH units, three years after application.

Although determined soil reaction was acid (pH(KCl) 4.60), AL-method showed quite high phosphorus availability level, due to prior phosphorus ameliorative fertilization. Obviously, because of very high soil phosphorus input its availability was less dependent on liming. However, significant increase of phosphorus content was observed at treatment with 18 t ha⁻¹ dolomite.

### Table 2 Influence of liming with dolomite on soil properties 3 years after application (Badljevina, 2009)

<table>
<thead>
<tr>
<th>Dolomite (t ha⁻¹)</th>
<th>pH H₂O</th>
<th>pH KCl</th>
<th>Humus %</th>
<th>AL-P₂O₅ mg 100 g⁻¹</th>
<th>AL-K₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5.68 a</td>
<td>4.60 a</td>
<td>1.90 c</td>
<td>50.43 b</td>
<td>19.77</td>
</tr>
<tr>
<td>6</td>
<td>6.17 a</td>
<td>5.58 a</td>
<td>1.98 c</td>
<td>52.50 b</td>
<td>21.53</td>
</tr>
<tr>
<td>12</td>
<td>7.33 a</td>
<td>6.76 a</td>
<td>2.05 bc</td>
<td>54.50 ab</td>
<td>20.97</td>
</tr>
<tr>
<td>18</td>
<td>7.32 b</td>
<td>6.74 b</td>
<td>2.24 ab</td>
<td>58.70 a</td>
<td>22.57</td>
</tr>
<tr>
<td>24</td>
<td>7.57 c</td>
<td>7.00 c</td>
<td>2.40 a</td>
<td>54.50 ab</td>
<td>22.20</td>
</tr>
<tr>
<td>LSD₀.₀₅</td>
<td>0.30</td>
<td>0.27</td>
<td>0.21</td>
<td>4.39 n.s.</td>
<td></td>
</tr>
</tbody>
</table>

Values followed by the same letter within each column are not significantly different at the 5% level

### Conclusions

Liming considerably influenced soil pH in both experiments. Effect of liming with carbocalk was statistically proved at all treatments. Carbocalk gradually raised soil pH from initial very acid reaction pH (KCl) 3.89 (control) to the slightly alkaline reaction pH (KCl) 7.30 at the overliming rate, while dolomite application affected pH only at higher rates. Regarding soil available phosphorus considerably higher effects of carbocalk compared to dolomite treatment were found. Four years after carbocalk application, phosphorus content was increased for 12 mg 100 g⁻¹ at the highest rate, while significant increase of soil available phosphorus (for 8.3 mg 100 g⁻¹) was determined at treatment with 18 t ha⁻¹ dolomite. Liming with carbocalk significantly decreased potassium availability at 45 t ha⁻¹ and higher rates, whilst dolomite didn’t affected soil potassium content.

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### References


