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RESIDUAL EFFECT OF LIMING ON SOIL PROPERTIES AND MAIZE GRAIN YIELD

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Abstract

The residual effect of liming on soil pH and plant available phosphorus and on maize grain yield was studied in the 2011 growing season. Field trial was conducted in 2006 in the east Croatia on the very acid luvisol with low phosphorus availability. Liming material containing 73 % CaO and 2-3% MgO was applied at following rates: 0, 5, 10, 20 and 40 t ha^{-1}. Liming gradually raised soil pH from initial very acid to even alkaline reaction on the highest rate. Also, available phosphorus content was considerably improved by liming. Significant liming impact on maize grain yield was ascertained, and it was higher on all liming treatments except on the 40 t ha^{-1}, due to overliming. The highest yield (11.9 t ha^{-1}) was achieved on the treatment with 10 t ha^{-1}, but between application of 5, 10 and 20 t ha^{-1} of lime there were no significant differences. So, liming with moderate lime rate proved to be effective five years after application.

Key words: *liming, soil pH, plant available phosphorus, maize grain yield*

Introduction

Acid soils occupy about 30% of the world's ice-free land area (von Uexkull and Mutert 1995). In Croatia the problem of natural and anthropogenic acidification of the soils has a great importance. There is about 1.6 million hectares of acid soils in Croatia (Bogunovic *et al.* 1997) and they are especially widespread in the eastern Croatia. Major causes of acidity are leaching and plant uptake of basic cations, production of organic acids from organic matter decomposition. Also, fertilisation, especially with some nitrogenous fertilisers containing strong acid forming anions, may increase acidity of soils with weak buffering capacity (Bierman and Carl, 2005). Under temperate climates long term losses of base cations from lower soil layer change the soil chemical properties and decrease nutrient avaliability. High levels of soil acidity (low soil pH) can cause reduction of root growth, nutrient availability, reduction of crop yields and deterioration of soil physical properties (Adams 1984). In general it affects the biological, chemical and physical properties of soil, which in turn affect the sustainability of crop production. In order to produce a better maize yield on acid soils, farmers are recommended to apply liming materials rich in calcium and magnesium to increase the soil pH and thus eliminate Al toxicity and increase nutrient avaliability, especialy phosphorus. Liming is common recommendations for improvement of acid soils in Croatia (Kisic et al. 2002, Kovacevic et al. 2006, Loncaric et al. 2006, Rastija et al. 2007, 2008, 2009, Kovacevic and Rastija 2010, Andric et al. 2012). The aim of this study was to provide data for sustainable cropping by evaluating the residual effect of liming on soil chemical properties and maize grain yield.

Material and methods

The field trial was conducted in Zelčin (eastern Croatia) at dystric luvisol with low pH and low nutrients availability (pH $_{KCl}$ =4.31, SOM=1.71 %, P_2O_5= 7.8 mg/100g and K_2O= 22.8 mg/100g). The experiment was setup in a randomized complete block design in four repetitions. The plot size was 44.8 m^2 (5.6m x 8m). In the March of 2006 soil were limed with different amount of hydrated calcite (73% CaO + 2-3% MgO) what resulted in five treatments: 0, 5, 10, 20 and 40 t ha^{-1}. The experimental plots were fertilized for maize in 2011 with 175 kg N ha^{-1}, 150 kg P_2O_5 ha^{-1} and 225 kg K_2O ha^{-1}. Maize hybrid OsSK 552 was sown at the last decade of April and harvested manually at the end of September.

Maize growing seasons of 2011 were characterized by lower precipitation for 135 mm and higher air temperatures for 1.9 ^oC as compared to the 30-year mean. However, in terms of precipitation distribution, the lowest amount were in August (only 4 mm) while in May and July were above long term mean. Air temperatures were higher in all months during maize growing season (Figure 1).

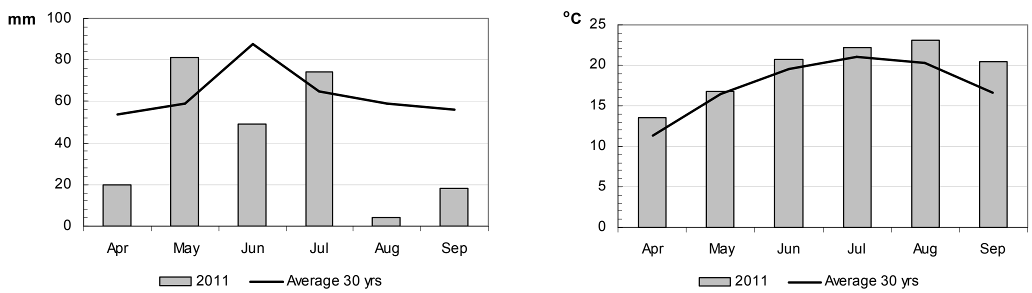

Figure 1. Monthly amount of rainfall (mm) and average air temperatures (°C) for maize growing seasons 2011 and 30-year mean values for the experimental site

The soil samples (0-30cm) were collected before fertilization (October 2010) and after harvest (October 2011). The soil pH (H_2O and M KCl, 1:5 v/v) were determined according to ISO (1994), plant available phosphorus and potassium by ammonium-lactate extraction (Egner et al., 1960) and soil organic matter content (SOM) by sulfocromic oxidation (ISO, 1998).

Yields were calculated on a 14% grain moisture basis. From each treatment, 10 cobs were used for determination of grain moisture and grain share in cob. Grain moisture was determined by electronic grain moisture instrument.

Data were statistically analyzed by single-factor ANOVA using SAS software (SAS Institute, Cary, NC, USA; PROC ANOVA), and the effects of liming on tested parameters were evaluated by t-test and least significant difference (LSD) at 0.05 probability levels.

Result and discussions

The results of the residual effect of liming on the soil chemical properties before and after growing season are shown in Table 1. The soil pH gradually raised from 5.29 by 5 t ha^{-1} calcite to 7.66 t ha^{-1} on overliming plots with 40 t ha^{-1} in the 2011. The same trend was observed one year before. This is in agreement with results from Andrić et al. 2012, where is indicated that liming with 5 and 20 t ha^{-1} lime raised pH for 0.5 and 2 pH units, respectively. Similar effect of liming was recorded by Kovacevic et al. 2006 and Rastija et al. 2008.

Table 1. Soil chemical properties

Liming t ha^{-1}	$pH(H_2O)$	pH(KCl)	P_2O5	K_2O	SOM
			mg/100g soil		%
Before growing season (October 2010)					
0	5.27	4.02	7.9	26.0	1.94
5	6.12	4.97	8.4	24.0	1.74
10	6.99	6.05	9.2	23.2	1.82
20	7.86	7.04	10.2	21.8	1.67
40	8.40	7.91	9.5	19.8	1.71
After growing season (October 2011)					
0	5.08	4.04	8.6	26.2	1.86
5	6.27	5.29	10.0	22.0	1.77
10	6.58	5.58	10.6	20.6	1.84
20	7.35	6.54	13.1	22.5	1.72
40	8.26	7.66	11.0	23.7	1.64

Liming also considerably affected phosphorus availability. The highest value of plant available phosphorus was achieved by the application of 20 t ha^{-1}, while the lower effect was determined with the highest calcite dose, probably due to slightly alkaline soil reaction (Table 1). Zhang et al. 2004 and Rahman et al. 2002 reported about impact of liming on phosphorus availability in acid soils, pointed that a moderate pH increase leads to greater phosphorus availability, while too high doses can cause its decreasing. Available potassium content in 2011 ranged from 20.6 to 26.2 mg/100g soil.

Table 2. Maize yield and grain moisture

Liming t ha^{-1}	Grain yield t ha^{-1}	Grain moisture %
0	9.24 b	22.8 a
5	10.97 a	21.3 b
10	11.88 a	21.5 b
20	10.74 a	21.5 b
40	9.10 b	22.2 a
Mean	10.38	21.8
F test	**	**
$LSD_{0.05}$	1.28	0.63

a - values followed by the same letter are not significantly different at $P \leq 0.05$ level

**significant at $P \leq 0.01$ level

The average grain moisture at harvest was relatively low (21.8%). On the control treatment, as well as on the treatment with the highest rate, significantly higher moisture content was found.

Considering less favourable weather conditions during maize growing season, satisfying mean grain yield of 10.38 t ha^{-1} was achieved (Table 2.). Liming significantly increased grain yield on all treatments, except on the highest calcite amount, where it stayed on the level of the control. This is probably consequence of overliming and slightly alkaline reaction what could lead to soil nutrients imbalance and microelements unavailability.

The highest yield was attained with 10 t ha^{-1} of lime (11.88 t ha^{-1}), and it was higher for 2.64 t ha^{-1} compared to control. However, between 5, 10 and 20 t ha^{-1} there were no significant differences, indicating that five years after liming its positive effects are still expressed as the yields on all treatments, except the last, were statistically significantly higher.

Conclusion

Significant liming impact on soil chemical properties and maize grain yield was ascertained. Application of different rates of hydrated lime gradually raised soil pH from acid to slightly alkaline reaction. Available phosphorus content was improved by higher liming rates, but the soil is still remained at the low level of phosphorus supply, indicating that liming of acid soil should be implemented along with rich phosphorus fertilization. Maize grain yield was significantly higher on the all liming treatments except on the 40 t ha^{-1}, due to overliming. As between 5, 10 and 20 t ha^{-1} of lime there were no statistical differences, it can be concluded that liming with moderate amount could be effective five years after application.

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