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IMPACT OF LIMING WITH FERTDOLOMITE ON GRAIN YIELD OF FIELD CROPS

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Abstract

The stationary field experiment was conducted in spring of 2004 on Pavlovac (Bjelovar-Bilogora County-Croatia) very acid soil (pH in 1n KCl = 3.80) by the application of NPK 10:30:20 fertilizer as follows (kg ha^{-1}): a = 0 (the conventional fertilization); b = a + 416; c =1249; d = 2028; e = 2916; f = 3748. Differences of N amounts added by fertdolomite were equalized by CAN (calcium ammonium nitrate: 27% N). The experiment was conducted in four replicates and the basic plot size was 77 m^2. Two replicates of the experiment was limed in autumn of 2007 by granulated fertdolomite (24.0 % CaO + 16.0 % MgO + 3.0 % N + 2.5 % P_2O_5 + 3.0 % K_2O) in amount 10 t ha^{-1}. Two subplots from each replicates were harvested in order to obtain four replicates of grain yield data for each treatment. In this study was shown survey grain yield of field crops grown in rotation for 5–year period 2008–2012 (maize – maize – soybean – maize – winter wheat). Mean yields of the field crops in the experiment were as follows (t/ha): 11.64, 10.70 and 9.02 (maize 2008, 2009 and 2011, respectively), 3.57 (soybean 2010) and 7.59 (wheat 2012). Response to liming was depended on the growing season (year effect) and field crop. As affected by liming, yields of maize were significantly increased for 5% (2008 and 2009) and for 8% (2011). Also, yields of wheat were similar for unlimed and limed plots in 2012 (7.64 and 7.54 t/ha, respectively). However, soybean responded to liming in 2010 by yield increases for 18% (3.28 and 3.85 t/ha, respectively).

Key words: *liming, grain yield, maize, wheat, soybean*

Introduction

Increase of crop production is present in numerous countries over the world which raises need for arable land. Maximum yields of field crops are possible only when producers meet plant nutritional requirements and other basic production factors. For decades, one of the most common constraint of low soil fertility is soil acidity. Soil acidity is global problem because of estimation that acid soils occupy about 30% (3.95 b ha) of the world's ice-free land area (von Uexkull and Mutert, 1995). Crop production systems undergo accelerated soil acidification as a consequence of anthropogenic inputs and outputs. Plant growth-limiting factors in acid soils include deficiencies (N, P, Ca, Mg, Mo, Zn) and toxicities (Al, Mn, Fe, H) of elements. Acid soils are widespread in Croatia and they cover 831.704 ha, representing about 32% of total agricultural land (Mesic et al., 2009).
Increase in pH, cation exchange capacity and base saturation were expected to improve vitality and growth of crops. Thus, liming, the application of calcitic materials to soil, is increasingly used in acidic soils and represents general recommendation for short-term and long-term improvement of acid soil fertility (Mesic, 2001; Rengel, 2003). Liming improves the characteristics of soil through its direct effect on the amelioration of soil acidity and through its indirect effects on the mobilisation of plant nutrients and promote humus decomposition. Various materials may be applied for acidity correction, as long as the product is constituted by neutralizing components such as calcium and/or magnesium oxides,

hydroxides, carbonates and silicates (Castro and Crusciol, 2013). Costa and Rosolem (2007) reported that lime application, as an investment in soil productivity, lasts about three growing seasons, but there are findings that benefit of liming can have subsequent effects (Caires et al., 2008; Kovacevic et al., 2012).

According to Statistical Yearbook of the Republic of Croatia (2013) in 5-year period from 2008 to 2012 average total arable land in Croatia is 882 752 ha of which wheat, maize and soybean sown area occupies 19%, 34% and 6%, respectively of total arable land with average yield of 5 t ha^{-1}, 6 t ha^{-1} and 3 t ha^{-1}, respectively.

Aim of this study was testing effects of liming by dolomite enriched with nitrogen, phosphorus and potassium (commercial name fertdolomite) on yields of maize, soybean and wheat under stationary field experiment conditions.

Material and methods

The stationary field experiment was conducted in spring of 2004 on Pavlovac (Bjelovar-Bilogora County-Croatia) very acid soil (pH in 1n KCl = 3.80) by the application of NPK 10:30:20 fertilizer as follows (kg ha^{-1}): a = 0 (the conventional fertilization); b = a + 416; c =1249; d = 2028; e = 2916; f = 3748. The experiment was conducted in four replicates and the basic plot size was 77 m^2. The applied methods, weather characteristics and results of the first four years of the experiment were shown in detail by the previous studies (Kovacevic et al., 2006; Rastija et al., 2006).

Two replicates of the experiment was limed in autumn of 2007 by granulated fertdolomite (24.0 % CaO + 16.0 % MgO + 3.0 % N + 2.5 % P_2O_5 + 3.0 % K_2O) in amount 10 t ha^{-1}. Two subplots from each replicates were harvested for receiving four replicates of grain yield data for each treatment.

Soil and weather characteristics, methods of experimentation and the results were in details elaborated by the previous studies (Kovacevic et al., 2011; Iljkic et al., 2013; Josipovic et al., 2013; Stojic et al., 2014).

Results and discussion

In general, a positive response of maize, soybean and wheat to lime is expected. In the 5-year period from 2008 to 2012 maize was grown in three growing seasons and average yields in the experiment were in range from 9.02 (2011) to 11.64 (2008) t ha^{-1}.

Table 1. Response of the field crops to liming

Fertdolomite (autumn 2007)	Grain yield (t ha^{-1})* in 5–year period 2008 – 2012				
	2008	2009	2010	2011	2012
	Maize	Maize	Soybean	Maize	Wheat
0 (control)	11.36	10.40	3.28	8.67	7.64
10 t ha^{-1}	11.92	11.00	3.85	9.38	7.54
LSD 0.05	*0.27*	*0.47*	*0.21*	*0.57*	*ns*
Average yield	11.64	10.70	3.6	9.0	7.6
Liming effect	+ 4.9%	+ 5.8%	+ 17.4%	+ 8.2%	0
* averages of five PK-fertilization and four replicates (20 individual results)					

Response to liming was depended on the growing season (year effect) and field crop. As affected by liming, yields of maize were significantly increased about 5% (2008 and 2009) and 8% (2011). Also, wheat yield were quite similar for unlimed and limed plots in 2012. However, soybean responded to liming in 2010 by increase yield for about 18% (Table 1).

In general, legumes are known to be more responsive to liming than other crops (Soon and Arshad, 2005). Soil acidity results with lower occupancy of root nodules and there is less potential for N_2 fixation than those in limed soil (Stevovic, et al., 2010; Yanjun et al., 2010; Milakovic et al., 2012).

Liming is known to positively influence Ca and Mg nutrition in soybean and maize yield due to better development of the root system (Caires et al., 2008). Increasing the pH of acid soils by liming resulted in increased N mineralization, which have a positive effect on field crops yield. Even though, response of maize to liming was mainly moderate probably because of the other limitation of the soil fertility, for example unregulated air–water relations and low humus contents.

Weather characteristics, particularly precipitation quantity and distribution as well as temperature regime during growing season, have important impact of field crop yields, but adequate fertilization stabilizing yield differences among years. In general, the lower yields of maize are in close connection with drought and high air temperature stress (Kovacevic and Rastija, 2010; Komljenovic et al., 2010; Andric et al., 2012; Kovacevic et al., 2012; Stojic et al., 2012; Rastija et al., 2012; Videnovic et al., 2013). Antunovic et al. (2012) reported that in unfavorable weather conditions (water shortage followed by higher air–temperatures) nutrient supply can fade which result in lower soybean yield (2.4 t ha^{-1}).

Caires et al. (2008) reported that applying lime material (dolomitic lime, 176 g kg^{-1} Ca and 136 g kg^{-1} Mg) did not have significant influence on maize and soybean yield, whereas wheat yield increase for 115% as compared to the control. In 3-year experiment Costa and Rosolem (2007) use lime rates (199 g kg^{-1} of Ca, 138 g kg^{-1} of Mg), ranging from 0.0 to 9.0 t ha^{-1}, of which 4.5 t ha^{-1} lime in 1st year of the experiment resulted with higher yield of soybean (cultivar Embrapa 58) for 36% and wheat (cultivar Iapar 29) for 13%, as compared to no limed treatment. In spite of the fact that benefit of liming can have a positive long-term effects on field crops, in our study five years after fertdolomite application, wheat yield was not affected by lime application.

Conclussion

Liming with fertdolomite had different effects on grain yields depending on the growing season and field crop. In general, these effects were mainly moderate probably because of the other limitation of the soil fertility, for example, non–regulated air–water relations, low humus contents etc. Furthermore, in unfavorable weather conditions like lack of rainfall followed by higher air–temperatures real benefit of liming can fade.

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