IMPACTS OF LIMING WITH DOLOMITE ON THE WHEAT YIELD

D. Iljkic[1], M. Rastija1, G. Drezner[2], K. Karalić[1], R. Sudar[2]

[1] Josip Juraj Strossmayer University of Osijek, Faculty of Agriculture, Trg Sv. Trojstva 3, HR-31000 Osijek, Croatia

[2]Agricultural Institute Osijek, Juzno predgradje 17, 31000 Osijek, Croatia

E-mail: dario.iljkic@pfos.hr

ABSTRACT

The stationary field experiment with increasing rates of dolomite meal (56% CaO + 40% MgO) was started in spring of 2003 in Badljevina (Pakrac municipality, Pozega-Slavonia County) on very acid soil (pH in 1n KCl 3.74). Total four treatments of dolomite were applied on ordinary fertilization (160 N + 100 P2O5 + 130 K2O) as follows: a = control (without dolomite); b = a + 5 t ha-1; c = a + 10 t h-1 and d = a + 15 t ha-1. The field trial was conducted in four replicates (basic plot size 92.4 m2). In the next years (2004-2009) the experiment was fertilized uniformly in level of the ordinary fertilization. Crop sequence for the 2003 - 2009 period was as follows: maize (2003 – 2005) – spring barley (2006) – maize (2007). Residual effects of liming on winter wheat yields in 2009/2010 growing season were found because unlimed plots yielded 2.92 t ha-1 while liming effects were up to 18% (range from 3.24 to 3.44 t ha-1). Number of spikes per area unit is main reason for yield increasing on limed treatments. Liming was mainly considerable effects on yields of the previous crops in the 2003 - 2007 period. The grain yield of maize was influenced by liming in four years and yield was significantly increased at all liming treatments compared with control. Maize responded to liming by increasing grain yield for 15% (2003), 25% (2004), 150% (2005) and 50% (2007), while spring barley yield were increased by liming for 20% (2006).

Key words: liming, wheat yield, grain quality parameters

Acknowledgments: These investigations were supported by Croatian Ministry of Science, Education and Sport (the project 079-0730463-0447).

INTRODUCTION

In many cases soil acidity is limiting factor of arable crops yield worldwide (Adams, 1984). According to some author soil acidity is one of the most prevalent problems in production of food and fiber because at least 40%, and by some estimates as much as 70%, of the world's arable land is affected (Rengel, 2003). In general, liming is one of the usual recommendations for improvement of acid soil (Sumner, 1997; Raij et al., 1997). In Croatia there are around 1.6 million hectares or about 30% of acid soils (Bogunovic et al., 1997) which in combination with the weather characteristics represent major problem for the highest and stabile yields of the field crops (Kovacevic et al., 2006, 2007, 2010, 2010a, 2010b, 2010c, 2011; Rastija et al., 2010). The aim of this study was testing the residual impacts of liming on winter wheat properties.

MATERIAL AND METHODS

The field experiment

The field experiment with increasing rates of dolomite meal (56% CaO + 40% MgO) was conducted at beginning May of 2003 on Badljevina (Pakrac municipality, Pozega-Slavonia County) acid soil. Total four treatments of dolomite were applied on ordinary fertilization (160 N + 100 P_2O_5 + 130 K_2O) as follows: a = control (without dolomite); b = a + 5 t ha^{-1}; c = a + 10 t h^{-1} and d = a + 15 t ha^{-1}. The field trial was conducted in four blocks each of 369.6 m^2 area ordered in sequence of treatments from a to d. Each block was divided in four subplots of 92.4 m^2 which represented four replicates. In the next years (2004 - 2009) the experiment was fertilized uniformly in level of the ordinary fertilization. Crop sequence for the 2003 - 2009 was as follows: maize (2003 – 2005) – spring barley (2006) – maize (2007). These results were elaborated by the previous study (Kovacevic and Rastija, 2010).

Winter wheat (Triticum aestivum L.) (cultivar Zlata) was sown at November 3, 2009 and harvested in July 2, 2010. The spikes from square meter area were taken and enumerated from each experimental plot. They were harvested by special threshing machine. Wheat grain properties were determined as follows: grain yield (calculation on 13% grain moisture basis), number of spikes per area unit (m^2), 1000 grain weight, hectoliter mass, protein, starch, wet gluten and sedimentation value.

Soil and grain sampling, chemical and statistical analysis

Soil samples (0-30 cm) were taken from each basic plot in autumn of 2004 (Kovacevic and Rastija, 2010). 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). Grain samples of wheat for testing of quality parameters were collected at harvesting from 1 m^2 of area in levels of basic plot. Protein, starch, wet gluten and sedimentation value was determined by Near Infrared transmission spectroscopic method on Foss Tecator Infratec 1241 Grain Analyzer in the agrochemical laboratory of Agricultural Institute Osijek. The data were statistically analyzed

by ANOVA and treatment means were compared using t-test and LSD at 0.05 and 0.01 probability level.

Soil and weather characteristics

Soil of the experiment is very acid (pH in KCl 3.74) and supplied with adequate levels of plant available phosphorus and potassium (Table 3).

Weather conditions had considerable impacts on field crop yields including wheat (Iljkic et al., 2010; Kovacevic et al., 2010a, 2010c; Markulj et al., 2010; Marijanovic et al., 2010). In general, based on monthly values of precipitation and air-temperatures is difficult definition of weather influences on wheat grain yields in individual growing season (factor "year"). However, there are indications that the lower yields of wheat are mainly in connection with oversupplies of water, especially in the autumn/winter period (Josipovic et al., 2005).

The 2009/2010 growing season characterizing considerable more precipitation (close to 60% more compared to long-term mean and air-temperature higher for 0.7 °C (Table 1). May and June were especially wet (148% more than long-term mean) and these two months participated with 45% of total precipitation in October-June period. Under these conditions considerable attacks of plant diseases, decreasing of hectoliter mass and 1000 grain weight were found (Drezner – unpublished data).

Table 1. Precipitation and mean air-temperatures (Daruvar Weather Bureau)

Year of harvest	Precipitation and mean air-temperatures in Daruvar (air-distance from the experiment: 10 km in north direction): 2009/2010 and LTM (30-year mean: 1961-1990)									
	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	
	Precipitation (mm)									Sum
2010	66	86	99	91	70	58	80	197	262	1009
LTM	64	82	66	55	49	58	77	86	99	636
	Mean air-temperature (°C)									Mean
2010	11.0	8.5	3.8	-0.8	1.9	6.6	11.5	15.8	19.7	8.7
LTM	10.9	5.8	1.4	-0.4	2.1	6.2	11.0	15.7	18.9	8.0

RESULTS AND DISCUSSION

In general, very low yields of wheat, especially on the control treatment, were achieved in the experiment. Low realization of spikes per area unit is the main reason for low yield on the unlimed treatment. However, due to liming number of spike/m^2 was increased up to 50% and grain yield for 18% compared to the control treatment (Table 2). Also, liming resulted by improving of the parameters of grain quality but differences of sedimentation values and protein contents were non-significant (Table 2). Based on the experiences from Agricultural institute Osijek (Sudar – unpublished data), wheat harvested in 2010 year characterizing a high protein and wet gluten contents as well as a high sedimentation value which indicates on a good protein quality.

Table 2. Residual impacts of liming with dolomite meal (spring 2003) on the wheat yield (2010)

Liming by dolomite (t ha^{-1}) in spring 2003	Response of wheat (the growing season 2009/2010) to liming: grain yield, spikes number/m^2 and grain quality parameters: thousand grain weight (TGW), hectoliter mass (HM), sedimentation (Sedim.), contents of protein, starch and wet gluten							
	Yield (t ha^{-1})	Spikes (sp./m^2)	TGW (g)	HM (kg)	Sedim. (ml)	% in dry matter		
						Proteins	Starch	Wet gluten
0	2.92	401	30.63	77.7	65.9	18.23	63.64	45.01
5	3.44	603	30.24	78.4	65.2	18.02	64.08	45.25
10	3.34	609	29.22	77.9	66.5	18.53	62.71	46.64
15	3.24	576	30.77	77.5	66.9	18.63	62.93	46.57
Average	3.23	547	30.21	77.9	66.1	18.35	63.34	45.87
LSD 5%	0.40	62	ns	ns	ns	ns	0.65	0.87
LSD 1%	ns	89					0.99	1.31

Table 3. Impacts of liming on soil status and grain yields (Kovacevic and Rastija, 2010)

Impacts of liming (spring 2003) by dolomite on soil status and grain yields of maize and barley									
Lime t/ha	Soil (0-30 cm) in Oct. 2004				Grain yield (t ha^{-1}) and growing season				
	pH		mg/100g		Maize				Barley
	H_2O	KCl	P_2O_5	K_2O	2003	2004	2005	2007	2006
0	4.50	3.74	17.2	21.7	6.75	9.82	3.72	3.60	2.70
5	5.68	4.90	17.7	21.8	7.49	11.76	8.05	4.04	2.94
10	6.29	5.71	21.2	23.2	7.53	12.29	9.35	4.72	2.86
15	6.86	6.36	22.8	23.2	7.76	12.01	8.72	5.40	3.24
LSD 5%	0.27	0.37	2.99	ns	0.93	0.68	0.90	0.72	0.30

Liming with dolomite meal significantly increase the soil pH and phosphorus availability (Table 3). Significant increase of plant available phosphorus was achieved in treatment with 10 and 15 t ha^{-1} dolomite, respectively. It is generally known that reducing of soil acidity leads to increased phosphorus availability (Gaume et al., 2001). Liming did not affect potassium availability, being in the optimal range (Kovacevic and Rastija, 2010).

The grain yield of maize was influenced by liming in all four years and yield was significantly increased at all liming treatments compared with control. However, between rates of 15 and 10 t ha^{-1} dolomite no significant difference was found. In the first year of research maize responded to lime application by increasing grain yield for 15%, and in the second year by 25%. The best response was observed in 2005 and 2007 when grain yields increased by 150% and 50%, respectively. Also, liming significantly affected barley ears number and grain yield four years after dolomite application, but only at the highest rate, where yield increase for 20% is achieved (Table 3).

CONCLUSIONS

In general, very low yields of wheat, especially on the control treatment, were achieved in the experiment. Liming with dolomite reflected considerably on wheat yields in the 2009/2010 growing season because yields were increased up to 18% compared to unlimed plot. Also, liming considerably influenced on maize and barley yields but response of maize was very different depending on weather characteristics (factor "year").

REFERENCES

Adams F. (1984): Soil acidity and liming (Second edition). American Society of Agronomy, CSSA, SSSA Publishers, Madison, Wisconsin, USA.

Bogunovic M., Vidacek Z., Racz Z., Husnjak S., Sraka M. (1997): Namjenska pedološka karta Republike Hrvatske 1: 300000. Agronomski fakultet Zagreb.

Egner H., Riehm H. and Domingo W.R. (1960): Untersuchungen uber die chemische Bodenanalyse als Grundlage fur die Beurteilung des Nahrstoffzustandes der Boden II. Chemische Extractionsmetoden zu Phosphorund Kaliumbestimmung. K. Lantbr. Hogsk. Annlr. W-R. 26: 199-215.

Gaume A., Machler F., De Leon C., Narro L. and Frossard E. (2001): Low-P tolerance by maize (*Zea mays* L.) genotypes: significance of root growth, and organic acids and acid phosphates root exudation. Plant and Soil 228:253-264.

Iljkic D., Kovacevic V., Kovacevic J., Lalic A. and Drezner G. (2010): Weather impacts on yields of wheat and barley. In: Proceedings of 45th Croatian and 5th International Symposium of Agriculuture, Opatija 15-19 February 2010 (Maric S. and Loncaric Z. Editors), Faculty of Agriculture in Osijek, p. 737-740.

ISO (1994): Soil quality, Determination of pH, ISO 10390:1994.

ISO (1998): Soil quality, Determination of organic carbon by sulfochromic oxidation, ISO14235:1998.

Josipovic M., Kovacevic V., Petosic D. and Sostaric J. (2005): Wheat and maize yield variations in the Brod-Posavina area. Cereal Research Communications 33 (1):229-233.

Kovacevic V., Andric L., Banaj D. and Jambrovic A. (2010): Impacts of liming on maize and soil status. Növénytermelés, Vol. 59. Suppl., p. 61-64.

Kovacevic V., Banaj D., Kovacevic J., Lalic A., Jurkovic Z. and Krizmanic M. (2006): Influences of liming on maize, sunflower and barley. Cereal Research Commun. 34 (1): 553-556.

Kovacevic V., Josipovic M., Kaucic D. and Iljkic D. (2010a): Weather impacts on yields of maize, sugar beet, soybeans and sunflower. In: Proceedings of 45th Croatian and 5th International Symposium of Agriculuture, Opatija 15-19 February 2010 (Maric S. and Loncaric Z. Editors), Faculty of Agriculture in Osijek, p. 796-800.

Kovacevic V. and Rastija M. (2010b): Impacts of liming by dolomite on the maize and barley grain yields, Poljoprivreda 16:2010 (2) 3-8.

Kovacevic V., Seput M., Andric L. and Sostaric J. (2007): Response of maize and soybeans to fertilization with phosphorus and potassium on acid soil. Cereal Research Commun. 35: 2. 645-648

Kovacevic V., Sostaric J., Rastija M., Iljkic D. and Markovic M. (2010c): Weather characteristics of 2009 with aspect of spring field crops growing in Pannonian region of Croatia. Agrar- es Videkfejlesztesi Szemle 2010, vol. 5. (1) supplement (CD issue), Szegedi Tudomanyegyetem Mezogazdasagi Kar (Editor Horvath J.) p. 350-356.

Kovacevic V., Sudaric A., Sudar R., Rastija M. and Iljkic D. (2011): Residual impacts of liming and fertilization on soybean yield and quality. Novenytermeles , Vol. 60 Suppl 2, p. 259-262.

Markulj A., Marijanovic M., Tkalec M., Jozic A. and Kovacevic V. (2010): Effects of precipitation and temperature regimes on maize (*Zea mays* L.) yields in northwestern Croatia. Acta Agriculturae Serbica, Vol. XV, 29: 39-45.

Marijanovic M., Markulj A., Tkalec M., Jozic A. and Kovacevic V. (2010b): Impact of precipitation and temperature on wheat (*Triticum aestivum* L.) yields in eastern Croatia. Acta Agriculturae Serbica, Vol. XV, 29: 117-123.

Raij van B. and Quaggio J. A. (1997): Methods used for diagnosis and correction of soil acidity in Brazil: an overview. In: Plant-Soil Interactions at Low pH (Moniz A. C. et al., editors). Campinas, Brazil, Brasilian Society of Soil Science. p 205 - 214.

Rastija M., Simic D. and Lalic A. (2010): Imapcts of liming with dolomite on maize, wheat and barley grain yields. Növénytermelés, Vol. 59. Suppl., p. 65-68.

Rengel, Z. (2003.): Handbook of soil acidity, University of Western Australia Perth, Western Australia, Australia, Marcel Dekker AG, Basel, Switzerland.

Sumner M. E. (1997): Procedures used for diagnosis and correction of soil acidity: A critical review. In: Plant-Soil Interactions at Low pH (Moniz A. C. et al., editors). Campinas, Brazil, Brasilian Society of Soil Science. p.195 – 204.