Impacts of Liming on Yields of Field Crops

Vlado Kovacevic [(1)], Djuro Banaj [(1)], Ivan Brkic [(2)], Domagoj Simic [(2)]

[(1)] University J. J. Strossmayer in Osijek, Faculty of Agriculture, Trg Sv. Trojstva 3, HR-31000 Osijek, Croatia; e-mail: vkovacevic@pfos.hr
[(2)] Agricultural Institute, Juzno predgradje 17, HR-31000 Osijek, Croatia

ABSTRACT

In this study, survey of three field experiment (I, II and III) of liming effects on field crop yields in the western Slavonia province (Croatia) was shown. The experiments with increased rates of carbocalk - waste of sugar factory - (five steps up to 90 t/ha and four steps up to 60 t/ha, for I and II, respectively) and dolomite meal (up to 15 t/ha - III) were conducted in autumn of 2000 (I and II) and spring of 2003 (III). The experiments were conducted in four replicates and basic plots measured 64.3, 87.5 and 92.4 m^2, for I, II and III, respectively. As affected by liming soil pH was increased as follows (initial and realized pH in 1nKCl): 3.89 and 7.30 (I), 3.42 and 6.87 (II), 4.20 and 6.87 (III).
Liming (I) resulted with considerable increases of field crop yields as follows: up to 50% and 36% (maize for 2001 and 2002, respectively), up to 49% (sunflower 2003) and up to 30% (barley 2004). In general, by application of carbocalk to level of 90 t/ha, yields drastically decreased mainly to level of control as affected by overliming.
Liming (II) considerably influenced on maize yields by increases up to 26% (4-year mean from 2001-2005) with variation these effects among the years from 7% to even 50%. Yields of sugar beet (2004) were increased up to 43% (30 and 43 t/ha, for 0 and 30 t/ha of lime, respectively).
Liming (III) resulted by maize yield increases for 22% (2003: mean of the trial 10.42 t/ha) and for 9% (2006: mean 12.41 t/ha). Also, winter barley more responded to liming (yield increase in 2007 for 33% (mean 7.70 t/ha) in comparison with winter wheat (yield increase in 2005 for 10%: mean 6.73 t/ha).

Keywords: maize, sugar beet, sunflower, winter barley, winter wheat, liming, Croatia

1. INTRODUCTION

Acid soils occupy nearly 30% (3.95 b ha) of the arable land area in both tropical and template belts of the world. The acidity in soils is produced by several factors including rainfall, climate and agricultural farming processes (Matsumoto, 2004).

Soil acidity is in many cases limiting factor of arable crops yield in Croatia. In general, liming and adequate soil and crop management practice of these soils is a usual recommendation for

Vlado Kovacevic, Djuro Banaj, Ivan Brkic, Domagoj Simic. “Impacts of Liming on Yields of Field Crops”. International Commission of Agricultural and Biological Engineers, Section V. Conference “Technology and Management to Increase the Efficiency in Sustainable Agricultural Systems”, Rosario, Argentina, 1-4 September 2009.

their improvement (Madjaric et al., 1971; Musac et al. 1982). The first report with regard to liming in Croatia appeared more than 200 years ago (Radic, 1989). Aim of this study was showing survey of liming effects on field crop yields in western Slavonia province of Croatia. These results were in detail elaborated in the previous studies (Antunovic, 2008; Jurkovic et al., 2008; Kovacevic et al, 2006, 2009; Rastija et al., 2009).

2. MATERIALS AND METHODS

Three field experiments including liming treatments (the experiment I, II and III) were conducted on acid soils on ordinary fertilization under conditions of western Slavonia in Croatia (Pozega-Slavonia County and Virovitica-Podravina County). In this study only field crop yields were shown. Weather conditions (precipitation and temperature regimes), yields, soil and plant nutritional status were elaborated by Antunovic, 2008, Jurkovic et al. (2008), Kovacevic et al. (2006, 2009), Rastija et al., 2009.

The experiment (I) with increased rates of air-dried carbocalk (waste of Osijek Sugar Factory, 39% CaO) was conducted in term November 8, 2000 on arable land of Kutjevo Agricultural Holding (near Pleternica village, Pozega lowland area, Pozega-Slavonian County). Liming treatments were as follows (t/ha): 0, 15, 30, 45, 60 and 90. The field trial was conducted in four replicates (experimental plot of fertilization 64.3m^2). Crop rotation for the 2001-2007 period on the experimental field was as follows: maize (2001) – maize (2002) – sunflower (2003) – winter barley (2004) – tobacco (2005) – maize (2006) – wheat (2007).

The experiment (II) with increased rates of air-dried carbocalk was conducted at the beginning of November 2000 on Sopje (Virovitica-Podravina County) in the amounts as follows: 0, 15, 30, 45 and 60 t/ha. The treatments were distributed in four blocks, each of 350 m^2 area. Four replicates were used for each block for maize (basic plot 14 m^2 = two 10-m rows) and sugar beet (5 m^2) yield determinations. Crop rotation for the 2001-2005 period on the experimental field was as follows: maize (2001-2002-2003) – sugar beet (2004) – maize (2005).

The experiment (III) with increased rates of dolomite meal (56% CaO + 40% MgO) was conducted in spring (April 20) of 2003 in Badljevina (west edge of Pozega-Slavonia County). Total four treatments of dolomite were applied as follows (t/ha): 0, 15, 30 and 60. The field trial was conducted in four blocks each of 369.6 m^2 area ordered in sequence from 0 to lime 60 t/ha. Each block was divided in four subplots of 92.4 m^2 which represented four replicates. Crop rotation was as follows: maize (2003-2004) – wheat (2005) – maize (2006) - winter barley (2007).

3. RESULTS AND DISCUSSION

Liming treatments considerably increased soil pH (1n KCl) from initial 3.89, 3.42 and 4.20 to 7.30, 6.87 and 6.86, for the experiments, I, II and III, respectively (Table 1).

Table 1. Chemical properties of soils

Property	Carbocalk applied in autumn of 2000 (t/ha)						LSD	
	0	15	30	45	60	90	5%	1%
	The experiment I (Kovacevic et al., 2006): soil status in July of 2004							
pH (H_2O)	5.33	5.81	6.52	7.12	7.35	7.72	0.25	0.34
pH (1nKCl)	3.89	4.71	5.80	6.62	6.95	7.30	0.32	0.44
	The experiment II (Antunovic, 2008): soil status in October of 2002							
pH (H_2O)	4.52	6.34	7.12	7.39	7.81		0.49	0.71
pH (1nKCl)	3.42	5.65	6.41	6.65	6.87		0.49	0.71
	The experiment III (Kovacevic et al., 2009): soil status in Oct. of 2004							
	Dolomite meal applied in spring of 2003 (t/ha)							
	0	5	10	15			5%	1%
pH (H_2O)	4.94	6.45	6.73	7.22				
pH (1nKCl)	4.20	6.08	6.22	6.86			0.29	0.41

Table 2. Response of field crops to liming (the experiment I)

Field crop	Growing season	Carbocalk (t/ha: November 8, 2000)						LSD	
		0	15	30	45	60	90	5%	1%
Maize	2001*	5.04	6.19	6.39	6.72	7.56	4.46	1.05	1.47
Maize	2002*	5.51	6.66	6.77	6.82	7.50	5.08	0.92	1.37
Sunflower	2003*	2.72	3.77	4.04	3.46	3.31	2.83	0.41	0.56
W. barley	2004*	5.79	7.50	7.29	6.82	7.05	6.51	0.76	1.06
Tobacco	2005	Leaf composition (Tursic et al., 2008)							
Maize	2006**	7.28	7.68	7.88	8.26	8.06	8.02	0.56	ns
W. wheat	2007**	5.04	6.77	7.03	7.25	6.66	6.33	0.34	0.47
Tobacco	2008	Leaf composition (Tursic et al., unpublished data)							

source: *Kovacevic et al., 2006; **Jurkovic et al., 2008

Liming with carbokalk (the experiment I) resulted with considerable increases of field crop yields (Table 2). For example, as affected by liming maize yields were increased up to 50% and 36%, for the 2001 and 2002 growing season, respectively. In both cases, application of 60 t/ha was the most effective treatment. By application of carbocalk to level of 90 t/ha, yields drastically decreased to level of control as affected by overliming. Sunflower also responded with yield increases as affected by liming but optimal level was treatment 45 t of lime/ha. Application of the higher quantities of carbocalk very significantly decreased sunflower yields. Response of barley to liming was specific in comparison with maize and sunflower because in all applied liming treatments yields were significantly higher in comparison to the control. Using the lowest lime rate resulted by yield increase for 30%. Overliming resulted by significant yield decreases in comparison with application 15 and 30 t of lime (Table 2).

Table 3. Response of field crops to liming (the experiment II: Antunovic, 2008)

Year	Carbocalk Nov. 2000 t/ha (B)					X	Carbocalk Nov. 2000 t/ha					X
(A)	0	15	30	45	60	(A)	0	15	30	45	60	
	Grain yield of maize (t/ha)						Realized plant density (RPD in %TPD)*					
2001	7.36	10.2	10.3	11.2	10.3	9.87	58.9	78.9	82.3	82.3	73.0	75.1
2002	9.89	10.5	10.7	11.2	12.5	10.9	88.6	89.5	91.3	91.9	89.9	90.2
2003	4.42	5.14	5.81	6.63	5.53	5.51	59.0	65.4	73.0	72.0	70.8	68.0
2005	7.48	7.96	7.66	7.80	8.00	7.78	79.4	81.7	78.4	80.7	79.0	79.8
X B	7.29	8.46	8.62	9.20	9.08	8.53	71.5	78.9	81.3	81.7	78.2	78.3
LSD 5%	A: 0.33		B: 0.38		AB: 0.77		* TPD = theoretical plant density					
LSD 1%	0.47		0.50		1.01		= 51020 plants/ha = 100% RPD					
	Properties of sugar beet root (residual effects of liming)											
Year	Carbocalk (t/ha)				Carbocalk (t/ha)				Carbocalk (t/ha)			
	0	30	60	X	0	30	60	X	0	30	60	X
	Yield (t/ha)				Sucrose (%)				Sugar yield (t/ha)			
2004	30.0	43.0	34.0	35.7	14.6	13.7	13.4	13.9	4.4	5.9	4.5	5.0

Liming (the experiment II) considerably influenced on maize yields by increases up to 26% (4-year mean) with variation these effects among the years from 7% to even 50%. Sugar beet yields were low (mean 36 t ha^{-1}) and by using carbocalk 30 t/ ha they were increased for 43%. However, by lime application of 60 t/ha yields were decreased to level of the control (Table 3). Also, liming was closely related to lower sucrose contents (Table 3).

Table 4. Influences of fertilization (spring of 2003) on grain yields (Kovacevic et al., 2009; Rastija et al., 2009)

Dolomite (April2003) (t/ha)	Realized plant densities (RD for maize = % of planned or PD; for wheat and barley = number of ears per m^2) and grain yields (Y in t ha^{-1}) from 2003 to 2007									
	Maize (2003)		Maize (2004)		W. Wheat (2005)		Maize (2006)		W. Barley (2007)	
	RD	Y	RD	Y	RD	Y	RD	Y	RD	Y
0	92.3	9.21	88.6	12.01	609	7.33	98.4	10.58	598	5.55
5	85.0	10.09	90.0	12.57	566	7.64	100.2	10.81	704	6.91
10	89.7	11.11	94.8	12.61	657	7.76	100.2	11.01	797	7.04
15	87.7	11.29	94.2	12.45	601	8.05	93.5	11.54	748	7.41
LSD 5%		0.97		n.s.		0.47		0.69	13	1.00
Average	88.7	10.42	91.9	12.41	608	7.70	97.2	10.99	711	6.73

* 100 % RD or RD (plants ha^{-1}) = 54946 (2003 and 2004), 57143 (2006) and 58310 (2008)

** maize yield calculations n 14% moisture and 90% (2003 and 2004) and 96% (2006) of PRD basis; yield calculation on 13% moisture, 600 (wheat) and 700 (barley) ears per m^2 basis.

In general, liming by dolomite meal (the experiment III) moderately influenced on grain yields of maize because they were significantly increased for 22% (the growing season 2003: 9.21 t/ha and 11.29 t/ha, for control and lime 15 t/ha) and up to 9% (the growing season 2006: 10.58 t/ha and 11.54 t/ha, respectively). However, in the second year of testing maize yields were similar for all applied treatments (mean 10.99 t/ha). Also, winter barley more responded to liming (yield increase for 33% in the growing season 2007: 5.55 t/ha and 7.41 t/ha, for the control and dolomite 15 t/ha) in comparison with winter wheat (yield increase for 10% in the growing season 2005: 7.33 t/ha and 8.05 t/ha, respectively) – Table 4.

Vlado Kovacevic, Djuro Banaj, Ivan Brkic, Domagoj Simic. "Impacts of Liming on Yields of Field Crops". International Commission of Agricultural and Biological Engineers, Section V. Conference "Technology and Management to Increase the Efficiency in Sustainable Agricultural Systems", Rosario, Argentina, 1-4 September 2009.

Liming effects on field crop yields under conditions of the Eastern Croatia for the decade 80,ies of the last century were elaborated in previous studies (Grgic,1991; Kovacevic et al. 1993; Antunovic et. al. 2002). In general, maize, soybean and barley grain yields increased due to liming by 10% or less than 10%, while wheat showed no response to lime application.

4. CONCLUSIONS

Soil reclamation including liming is important factor of yield increase and its stabilization among growing seasons. Liming effects are mainly different as affected by soil and growing season characteristics. Based on our results, for practical purposes, we could to recommend liming with carbokalk in amount 15 t/ha, as well as application other available lime materials (dolomite, calcite) up to same level. Previous detailed soil test could be source of useful information concerning possible effects of liming.

5. ACKNOWLEDGEMENTS

These investigations were supported by Ministry of Science of Republic of Croatia (the projects 070107, 079017 and 079-0730463-0447) and Agricultural Institute in Osijek.

6. REFERENCES

Antunovic, M. 2008. Liming influences on maize and sugar beet yield and nutritional status. *Cereal Research Communications* 36 (Supplementum): 1839-1842.

Antunovic, M., Kovacevic V., Banaj D. 2002. Influences of liming on field crops yields on pseudoglay soils. In: *Proceedings of the Union of Scientists- Rousse "Energy Efficiency and Agricultural Engineering,96-99,* Vol. 1 (editor Mihailov N.) Rousse, Bulgaria.

Grgic D. 1991. *Naknadni efekti kalcizacije i fosfatizacije u proizvodnji kukuruza na pseudoglejnom tlu u podrucju Valpova – Residual effects of liming and phospatization on maize production on pseudogley of Valpovo area* (Master Thesis), Fakultet poljor. znanosti Zagreb, Croatia.

Jurkovic, Z., M. Josipovic, G. Drezner, V. Jurkovic and D. Banaj. 2008. Residual effects of liming with carbocalk on maize and wheat status. *Cereal Research Communications* 36 (Supplementum): 767-770.

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

Kovacevic, V., B. Bertic and D. Grgic. 1993. Response of maize, barley, wheat and soybean to liming on acid soils. *Rostlinna Vyroba* 39 (1): 41-52**.**

Kovacevic V. , I. Brkic, D. Simic, M. Rastija, D. Rastija. 2009: Impacts of Liming with Dolomite on Yields of field crops: I. Maize. *Poljoprivreda* 1 (15) 2009, Faculty of Agriculture in Osijek, Croatia (in press).

Madjaric, Z., I. Musac, J. Mundweil and B. Martinovic. 1971. Produzeno djelovanje duboke obrade lesiviranog smedjeg tla Podravine u interakciji s gnojidbom na prinos kukuruza. *Savremena poljoprivreda* 19 (11-2):139-146.

Matsumoto, H. 2004. Preface In *Proceedings of the 6th International Symposium on Plant-Soil Interactions at Low pH*, August 1-5, 2004, Sendai, Japan. Japanese Society of Soil Science and Plant Nutrition (JSSSPN), Sendai, Japan.

Musac, I., I. Juric , V. Kovacevic, I. Zugec and S. Madjar. 1982. The productivity of pseudoglay soils in Slavonia and the chemical changes which occur in the surface layer after meliorative tillage. In: *Proc. ISTRO The Ninth Conference International Soil Tillage Research Organization*, 26-32 Osijek June 21-24, 1982.

Radic Lj. 1989. Jubilej – 200 godina brosure «Ubavistenie od lana i konoplje opravljanja za poljodilce» s prilogom o kalcizaciji. *Znan. praksa poljopr. prehramb. tehnol.* 19 (3-4):260-266.

Rastija M., V. Kovacevic, A. Lalic, G. Drezner. 2009. Impacts of Liming with Dolomite on Yields of field crops: II. Wheat and Barley. *Poljoprivreda* 1 (15) 2009, Faculty of Agriculture in Osijek, Croatia (in press).

Tursic, I., V. Kovacevic, D. Banaj, S. Husnjak and S. Zalac. 2008. Influences of liming on the heavy metal contents in tobacco leaves. In *Proc. 17th Intern. Symp. Of CIEC, 24-27 Nov. 2008, 53-57, NRC (Micronutrient Project),* Cairo – Egypt.