

INFLUENCES OF LIMING ON MAIZE, SUNFLOWER AND BARLEY

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Abstract

Aim of this study was testing of field crops (maize-maize-sunflower-winter barley rotation) to lime (carbocalk: waste of sugar factory, 39% CaO) application in five rates up to 90 t/ha. Field trial was conducted in autumn 2000 in four replicates. Liming with carbocalk 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 over liming. Concerning oil contents in sunflower grain, it was significantly higher compared to control for treatments 15, 30 and 45 t/ha, but similar for control and 60 t/ha. Using of 45 and more lime per hectare decreased grain quality of malting barley because protein contents were significantly increased.

Key words: carbocalk, liming, maize, sunflower, winter malt barley, grain yield, grain quality

Introduction

Acid soils occupy about 30% (3.95 b ha) of the world's ice-free land area (von Urskull and Mutert, 1995). Soil acidity is in many cases limiting factor of arable crops yield in Croatia (Antunovic et al. 2002; Kovacevic et al. 1993). In general, liming of these soils is a usual recommendation for their improvement. The first report with regard to liming in Croatia appeared more than 200 years ago (Radic, 1989). Ameliorative ploughing of acid soil on calcareous loess substrate to 100 cm of depth (Madjaric et al. 1971; Musac et al. 1982) increased soil pH (1N KCl) of surface soil layer from 4.5 to 6.7 and grain yield of corn from 5.36 (control ploughing to 25 cm) to 9.01 t/ha.

Material and methods

Field experiment

Field experiment with increased rates of 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 64.3m²). Crop rotation for the 2001-2004 period on the experimental field was as follows: maize (2001) – maize (2002) – sunflower (2003) – winter barley (2004). Spring crops were sown at beginning of May in planned (theoretical) plant density (TPD) 58310 and 62964 plants/ha, for maize (the hybrid OsSK552) and sunflower (the hybrid Fakir), respectively.

Sampling and chemical analysis

Soil sampling for determination of influences liming on pH and humus contents was made in term July 24, 2004. Soil samples were taken from each plot (total 24 mean samples) by auger up to 30 cm of depth. Mean sample contained 15 individual samples. Oil content in sunflower grain was determined by nuclear magnetic resonance (NMR) spectroscopy method. Protein

and starch content in grain of barley was determined by Near Infrared spectroscopic method on Foss Tecator ("Infratec 1241 Grain Analyzer").

Weather characteristics

Excess of precipitation in June and September, their shortage in July and August, as well high temperatures in August, are main characteristics of weather during growing seasons of maize in 2001. In general, precipitation regime during the growing season of 2002 was more favorable. In general, low yields of maize are oft in close connection with shortage of rainfall and the higher air-temperatures during July and August (Josipovic et al. 2005). The 2003 growing season characterized with drought stress and the higher air-temperatures. However, sunflower is mainly more tolerant to these conditions in comparison with maize. The 2004 growing season was favorable for winter malt barley (Table 1).

Table 1. Meteorological data (Slavonski Brod Weather Bureau)

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Month	Field crop in rotation and growing season (2001-2004)								Long-term period	
	Maize 2001		Maize 2002		Sunflower 2003		W. barley 2003/2004		period (1971-1990)	
	Mean air-temp. (°C) and precipitation (mm): Slav. Brod* Weather Bureau									
	°C	mm	°C	mm	°C	mm	°C	mm	°C	mm
Jan. (I)	2.5	87	-0.6	15	-1.3	71	-1.0	81	-0.6	44
Feb. (II)	4.0	20	5.8	64	-1.9	14	2.4	56	1.8	39
March (III)	10.2	81	8.8	23	6.3	7	6.0	39	6.4	46
April (IV)	11.0	73	11.1	107	11.1	23	12.2	170	10.7	56
May (V)	17.9	30	18.1	80	19.2	63	14.8	74	15.9	74
June (VI)	17.9	191	21.0	55	23.7	44	15.7	86	18.8	82
July (VII)	21.7	57	22.3	78	22.6	61	21.3	46	20.6	87
Aug.(VIII)	22.2	32	20.7	122	23.8	51	20.9	28	19.9	71
Sept. (IX)	14.5	224	15.0	136	15.7	48	15.7	49	15.9	54
Oct. (X)	13.6	11	11.3	80	9.5	167	13.5	98	10.3	61
Nov. (XI)	3.5	116	9.3	73	7.7	56	5.7	88	4.5	59
Dec. (XII)	-3.0	36	1.6	29	1.3	27	2.3	62	1.2	46
Total: I-XII		958		861		632		857		720
Mean I-XII	11.3		12.0		11.5		10.8		10.5	
Weather data for growing season period										
V-IX	18.8	534	19.4	471	21.0	217			18.2	471
X-VI							7.6	756	7.7	507

* about 20 km air-distanced from Pleternica in SE direction

Soil properties

Soil is characterized as a stagnic albeluvisol (FAO Classification) of Ap-E/E-Btg-C profile. Liming influence on increasing soil pH reaction was significant at all applied carbocalk amounts and within them. The humus content was significantly decreased by liming only with highest carbocalk amount (90 t/ha), although application of all but one lower carbocalk amounts resulted in lower humus content than in soil without liming (Table 2).

Table 2 : Influences of liming (November 8, 2000) on soil properties (July 2004)

Property	Liming with carbocalk (t/ha: November 8, 2000)						LSD	
	0	15	30	45	60	90		
	Soil status of surface area (0-30 cm) at July 2004						5%	1%
pH (H ₂ O)	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
Humus (%)	1.98	1.83	1.93	1.98	1.92	1.67	0.18	n.s.

Results and discussion

Liming with carbocalk resulted with considerable increases of field crop yields (Tables 3-5). 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. Yield trends were in close connection with FMS values, while PDR and GM values were similar for applied treatments (Table 3).

Table 3. Response of maize (hybrid OsSK552) to liming

Property*	Liming (t/ha) in term November 8, 2000						LSD	
	0	15	30	45	60	90	5%	1%
	Maize properties (the 2001 growing season)							
Yield (t/ha)	5.04	6.19	6.39	6.72	7.56	4.46	1.05	1.47
Female-sterile plants (%)	26.7	17.5	18.5	11.9	8.2	25.4	2.6	3.9
Plant density realization (%)	93.1	92.9	96.0	95.1	91.0	93.5	n.s.	
Grain moisture at harvest (%)	30.8	30.5	31.1	31.5	30.2	30.4	n.s.	
	Maize properties (the 2002 growing season)							
	0	15	30	45	60	90	5%	1%
Yield (t/ha)	5.51	6.66	6.77	6.82	7.50	5.08	0.92	1.38
Female-sterile plants (%)	19.7	14.2	13.0	10.3	9.2	20.9	1.9	3.4
Plant density realization (%)	88.4	89.2	92.1	89.5	92.9	89.0	n.s.	
Grain moisture at harvest (%)	28.7	28.7	30.0	30.1	29.6	30.4	n.s.	

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. In comparison to control treatment and lime application 60 t/ha, oil contents in sunflower grains were significantly higher for treatments 15, 30 and 45 t/ha. PDR values were independent on liming (Table 4). 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 5). Using of 45 and more lime per hectare decreased grain quality of malting barley because protein contents were significantly increased. However, starch contents were similar and independent on liming treatments. 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.

Table 4.: Response of sunflower (the hybrid Fakir) to liming

Property*	Liming (t/ha) in term November 8, 2000						LSD	
	0	15	30	45	60	90	5%	1%
Sunflower properties (the growing season 2003)								
Yield (t/ha)	2.72	3.77	4.04	3.46	3.31	2.83	0.41	0.56
Oil in grain (%)	49.98	51.03	50.75	50.62	50.32	47.58	0.45	0.62
Plant density realization (/%)	97.8	95.9	98.2	93.3	98.2	98.2	n.s.	

Table 5.: Response of winter malt barley (cultivar Rex) to liming (the 2004 growing season)

Property	Liming (carbocalk t/ha: November 8, 2000)						LSD	
	0	15	30	45	60	90	5%	1%
The fourth year of testing (2004): malt winter barley								
Yield (t/ha)	5.79	7.50	7.29	6.82	7.05	6.51	0.76	1.06
Ears number / m ²	408	575	585	573	535	549	61	84
Grain quality parameters								
Protein (%)	9.08	9.80	10.14	11.08	10.93	12.15	1.05	1.45
Starch (%)	62.81	63.00	62.96	62.64	62.27	61.92	n.s.	
Hectolitar mass (kg)	72.48	71.80	72.88	71.20	71.50	71.22	n.s.	
Mass of 1000 grains (g)	44.34	42.44	42.21	44.10	42.48	43.26	0.93	n.s.

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 carbocalk in amount 15 t/ha, as well as application other available lime materials (dolomite, calcite) up to same level. Previous more detailed soil test could be source of useful information concerning possible effects of liming.

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