RESPONSE OF WINTER BARLEY TO LIMING

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Abstract: The field experiment with increasing rates (0, 5, 10, 20 and 40 t ha^{-1}) of fertdolomite (24.0 % CaO, 16.0 % MgO, 3.0 % N, 2.5 % P_2O_5 and 3.0 % K_2O) was conducted in the autumn of 2008 in Badljevina (Pozega-Slavonian County). The experiment was conducted in the randomized block design in four replicates and basic plot size was 37.5 m^2. Acid reaction (pH in 1n KCl 5.08) and low levels of plant available P and K (AL-method: 8.3 mg P_2O_5 and 13.2 mg K_2O 100 g of soil) are main characteristics of the soil. Aim of this study was short review of published the 3-year results of the field crops in rotation and detailed results of unpublished data regarding response of winter barley in the 2012/2013 growing season. Application of the highest rate of fertdolomite resulted in the first year of testing by maize yield reduction for 12%, while in the remaining rates yield were in level of the control. In the next year winter wheat responded by yield increases up to 10%. As affected by the higher rates of ferdolomite (20 and 40 t ha^{-1}) grain yields of barley in the 2011 growing season were increased compared to the control for 20% and 51%, respectively. Also, barley considerably responded to grain yield increase in the 2013 growing season because yields were significantly increased for 15% and 44%, for the treatments 20 and 40 t ha^{-1}, respectively.

Keywords: fertdolomite, liming, yield, maize, winter wheat, winter barley

Introduction

Barley is beside maize and wheat, main field crop in Croatia. According to the data of FAO (faostat.fao.org), in the last 5-year period (2008-2012) the average agricultural land area of the country were 1312150 ha and used arable land 882525 ha. The harvested areas of maize were 302406 ha (mean yield 6.46 t ha^{-1} with range of variation among years from 4.34 to 7.98 t ha^{-1}), while analogical data for wheat were 168433 ha (5.06 t ha^{-1}; from 4.04 to 5.48 t ha^{-1}) and for barley 56574 ha (3.95 t ha^{-1}; from 3.27 to 4.26 t ha^{-1}). Yield variations among years are mainly result of weather characteristics (Kovacevic et al., 2013; Pepo and Kovacevic, 2011), while inadequate crop and soil management are reasons for the lower yield on the country level. Some limitations are possible to alleviate by liming and fertilization (Andric et al., 2012; Iljkic et al., 2013; Josipovic et al., 2013; Kovacevic et al., 2012, 2012b; Rastija et al., 2012, 2013; Stojic et al., 2012) as well as by choice of more tolerant hybrids (Kovacevic et al., 2012c). Aim of this study was response of barley to liming and fertilization.

Materials and methods

The field experimentand soil characteristics

The increasing rates of fertdolomite (24.0 % CaO, 16.0 % MgO, 3.0 % N, 2.5 % P_2O_5 and 3.0 % K_2O) were applied in four steps (amounts: 0, 5, 10, 20 and 40 t ha^{-1}) on the usual fertilization (for maize in 2009: 175 N + 52 P_2O_5 + 78 K_2O), which was used as a the control. In two next years (2010 and 2011), the experiment was fertilized uniformly in level of standard fertilization (for wheat and barley: 120 N + 35 P_2O_5 + 50 K_2O).

The experiment has been situated in the western part of Slavonia province (Pozega-Slavonian County). Choice of the soil was made based on the previous soil test. Acid reaction (pH in 1n KCl 5.08) and low levels of plant available phosphorus and

 DOI: 10.12666/Novenyterm.63.2014.Suppl

potassium (AL-method: 8.3 mg P_2O_5 and 13.2 mg K_2O 100 g of soil) are main chemical characteristics of the soil. Also, we observed that the soil is less permeable and incline to surface water stagnation after excessive precipitation.
Crop rotation was as follows: maize (2009) - winter wheat (2010) - winter barley (2011) – without crop (2012) – winter barley (2013). The results of the 3-year experimentation (2009-2011) were shown in the previous study (Kovacevic et al., 2012a).
Winter barley (cultivar *Rex*) was sown for need of livestock feeding in term October 15, 2012 and harvested in June 22, 2013. The NPK fertilizer 15:15:15 was ploughed and two top-dressings were made by the CAN (calcium ammonium nitrate: 27% N). Total amounts of the nutrients added by fertilization (kg ha^{-1}) were 176 N+38 P_2O_5+38 K_2O.
Harvesting of barley or grain yield and ears density determinations was made by cutting of ears from 4 x 0.25 m^2 areas (total 1.0 m^2) from each basic plot. After harvesting, the ears were enumerated and threshed by use of the threshing-machine constructed for threshing of the field experiments.

Sampling, quality parameters and statistical analysis
Grain samples for quality analysis were prepared from grains collected from 1.0 square meter of the harvested area. Protein content, starch content and hectoliter mass in the grain were determined by Near Infrared Transmittance spectroscopic method on Grain Analyzer (Infratec 1241, Foss Tecator) 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 5% probability level.

The weather characteristics
The 2013 growing season was mainly less favorable for winter barley growing, particularly on heavy and less permeable soils, because of excessive precipitation during the winter period with emphasis on February. Precipitation amounts in the October-June period were about 20% higher in comparison with the long-term mean. At the same period, air-temperatures were for 0.6 °C higher (Table 1).

Table 1. Precipitation and mean air-temperature in Daruvar

Daruvar Weather Bureau: precipitation (mm) and mean air-temperatures (°C)											
	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	Total	Mean
	The 2012/2013 growing season										
mm	92	64	120	83	113	91	69	82	56	770	
°C	11.0	9.1	0.9	1.8	2.0	4.8	12.5	15.8	19.2		8.6
	The long-term means (1961-1990)										
mm	64	82	64	55	49	54	54	59	88	634	
°C	10.9	3.8	1.4	-0.4	2.1	6.2	11.0	15.7	18.9		8.0
	Deviation of 2012/2013 (mm: + or – in %) in comparison with the LTM										
Prec.%	+44	-22	+88	+51	+131	+69	+28	+39	-36	+21	
°C + -	+0.1	+5.3	-0.5	+2.2	-0.1	-1.4	+0.5	+0.1	+0.3		+0.6

Results and discussion

Very low yields of barley (3.79 t ha^{-1}) were found in our experiment in the 2013 growing season, probably because of excessive precipitation (Table 1). In general, the colder winters and wet growing seasons, particularly those characterizing excess of precipitation in autumn/winter period, are less favorable for growing of winter barley (Paunovic and Madic, 2011). Winter barley was grown on this experiment in the 2010/2011 growing season (Table 3) and it was exposed by lower precipitation, particularly in January-April (40% lower compared to the LTM) period (Kovacevic et al., 2012a). Under these weather conditions were achieved considerable higher yields of barley (.26 t ha^{-1}).

However, yield response of barley in the 2013 growing season (Table 2) had similar trend like this in the 2011 because only application of the highest rate of fertolomite resulted by considerable yield increase for 28%. Also, in both cases, these yield differences are mainly results of ears density increases as affected by liming.

Thousand grain weight and hectoliter mass was independent on liming. However, the significantly higher protein content (10.7% compared to 9.6% on the control) was found by liming with 10 t of fertolomite, while by excessive liming (40 t ha^{-1}) protein content was drastically reduced to level of 7.7%. Starch contents values were similar with exception of application of the highest fertdolomite rate they were significantly increased for 1.2% (Table 2).

Table 2.: Impacts of liming (autumn 2008) on barley status (the growing season 2013)

Response of barley (the growing season 2012/2013) to liming: grain yield, ears density (ED) in square meter, thousand grains weight (TGW), hectoliter mass (HM), protein (prot.) and starch contents in grain											
Fertdolomite (Fertd.): November 8, 2008						Winter barley ((cultivar *Rex*) 2013					
Fertd.	Added by fertdolomite (kg ha^{-1})					Yield	ED	TGW	HM	Percent in grain	
t ha^{-1}	Cao	MgO	N	P_2O_5	K_2O	t ha^{-1}	e. $m2^{-1}$	g	kg	Prot.	Starch
0	0	0	0	0	0	3.35	475	42.3	64.6	9.6	60.1
5	1200	800	150	125	150	3.32	497	43.7	65.3	9.9	60.2
10	2400	1600	300	250	300	3.60	591	43.8	64.7	10.7	59.4
20	4800	3200	600	500	600	3.84	554	44.1	65.5	10.0	59.7
40	9600	6400	1200	1000	1200	4.83	590	42.1	65.2	7.7	61.3
					Mean	3.79	541	43.2	65.1	9.6	60.1
					LSD 5%	0.42	60	ns	ns	0.7	1.0

Table 3.: Review of the previous investigations (Kovacevic et al., 2012a)

Impacts of liming with fertdolomite (24.0 % CaO, 16.0 % MgO, 3.0 % N, 2.5 % P_2O_5 and 3.0 % K_2O) in autumn of 2008 on grain yield, plant density (PD: plants ha^{-1}), ears density (ED: the ears number in square meter area) and soil (0-30 cm depth) status									
Liming	Maize (2009)		Wheat (2010)		Barley (2011)		Soil (July 8, 2011)*		
(2008)	Yield	PD	Yield	ED	Yield	ED	pH	mg 100 g^{-1}	
t ha^{-1}	t ha^{-1}	pl. ha^{-1}	t ha^{-1}	e. $m2^{-1}$	t ha^{-1}	e. $m2^{-1}$	(KCl)	P_2O_5	K_2O
0	12.9	58300	5.61	670	6.14	691	5.08	8.3	13.2
5	13.4	58494	6.15	798	6.46	730	5.35	7.6	11.2
10	13.2	58300	6.14	800	7.08	784	6.00	11.2	13.7
20	13.4	58688	5.96	753	7.39	791	6.45	24.3	16.5
40	11.6	49585	5.94	766	9.25	927	6.90	42.4	28.2
LSD 5%	0.6	1055	0.51	90	1.19	130			

 DOI: 10.12666/Novenyterm.63.2014.Suppl

Application of the highest rate of fertdolomite resulted in the first year of testing by maize yield reduction for 12%, while in the remaining rates the yield were in level of the control. In the next year, winter wheat responded by yield increases up to 10% and the lowest rate of applied fertdolomite was adequate. As affected by the higher rates of ferdolomite (20 and 40 t ha^{-1}) grain yields of winter barley in the 2011 growing season were increased compared to the control for 20% and 51%, respectively (Table 2).

Conclusions

Liming in combination with fertilization is useful soil management practice with aim of increases yields of barley and the other field crops on the acid soils. However, these effects are close in connection with weather characteristics during individual growing season. With that regard, wet growing seasons in autumn/winter period are less favorable for winter barley, particularly on heavy and less permeable soils.

Acknowledgements

The experiment was conducted on Tihomir Drkulec Family farm (Badljevina, municipality Pakrac, Pozega-Slavonian County). These investigations have been supported by Ministry of Science, Education and Sport (the project 079-0730463.0447), Agricultural Institute Osijek and Petrokemija Fertilizer Factory Kutina, Croatia.

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