RESPONSE OF MALTING WINTER BARLEY TO AMELIORATIVE NPK-FERTILIZATION

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Abstract: *Barley covering about 7 % of arable lands in Croatia (56157 ha/year for 2005-2007). Mean yields of barley in this period was 3.56 t/ha with variation among the year from 3.23 to 3.82 t/ha. Close to 50% of barley growing areas have been distributed in Eastern Croatia region (22 % of the state territory). Aim of this study was testing residual response of malting winter barley to ameliorative NPK 7:20:30 fertilization (April 2003: a = 0 + standard fertilization kg/ha: 125 N + 80 P_2O_5 + 120 K_2O; b = a+1250; c = a+2500 and d = a+3750 kg/ha). Nitrogen (N) for the a-d treatments were equalized by addition of CAN (calcium ammonium nitrate) in the amounts 974, 649, 325 and 0 kg/ha, for the a, b, c and d, respectively. The experiment was conducted in four replicates by randomized block design (the basic plot 92.4 m^2). In the next years (2004-2006) only standard fertilization was applied and residual effects of ameliorative fertilization were tested. Malting winter barley (cultivar Lord) was sown at beginning of November 2005 and harvested in term of June 21, 2006. Water shortage in October and November (Daruvar: 38 mm precipitation vsv146 mm for 30-y mean 1961-1990), two-fold higher precipitation in December (131mm vsv 66 mm), the colder winter (mean air-temp. in January-March: 1.5 ^oC vsv 2.6 ^oC) and remaining part of barley growth in level close to long-term means, are main characteristics of the 2005/2006 growing season. Fertilization had considerably residual effects on grain yields of winter barley. Under standard fertilization barley yielded 5.42 t/ha. By using of 2500 and 3750 kg NPK 7:20:30 grain yields were increased for 6 % (5.75 t/ha) and 24 % (6.73 t/ha) respectively. However, hectolitre mass, protein and starch contents were independent on the fertilization.*

Key words: *winter malting barley, fertilization, phosphorus, potassium, grain yield*

INTRODUCTION

Wheat and barley are main small grain field crops in Croatia. In the 3-year period (means 2005-2007) wheat covered close to 20 % (165721 ha/ year) and barley 7 % (56157 ha/ year) ha of arable lands of the country. Mean yields of barley for the three-year period 2005-2007 was 3.56 t/ha with variation among the year from 3.23 to 3.82 t/ha. Close to 50% of barley growing areas have been distributed in the Eastern Croatia region which covering about 22% of the state territory (ILJKIC et al., 2010). Barley production in Croatia is low in comparison with needs of Croatian market. For example, needs of new malting plant situating close to Nova Gradiska are 60 thousand tones per year and they are covered by Croatian malting barley production less than 50%. For covering these needs, it is estimated malting barley harvesting area about three-fold compared to recent status (KOVACEVIC et al., 2009). Grain yields of malting barley and their quality are depending on many factors including waether and soil characteristics, crop management practices, especially fertilization and hereditary factors as well. Aim of this study was testing the residual response of malting winter barley to NPK-fertilization.

MATERIAL AND METHODS

The field experiment, sampling and chemical analysis

Four fertilization treatments by application of NPK 7:20:30 fertilizer (the product of Petrokemija Fertilizer Factory Kutina, Croatia): *a* = 0 + standard fertilization kg/ha: 125 N + 80 P_2O_5 + 120 K_2O), *b* = a+1250, *c* = a+2500 and *d* = a+3750 kg ha^{-1}) were applied on Korenicani soil (municipality Djulovac, Bjelovar-Bilogora County) in term of April 17, 2003. Different amounts of nitrogen (N) for the *a-d* treatments were equalized by addition of CAN (calcium ammonium nitrate) in the amounts 974, 649, 325 and 0 kg ha-1, for the *a*, *b*, *c* and *d*, respectively. The experiment was conducted in four replicates by randomized block design. Gross of the basic plot was 92,4 m^2 (11.0 m x 8.4 m). In the next years (2004-2006) only standard fertilization was applied and residual effects of ameliorative fertilization were tested. Crop rotation on the experimental field was as follows: maize (2003) – maize (2004) – maize (2005)-winter barley (2006). Response of maize to applied fertilization for 3-year period was shown by KOVACEVIC et al. (2007).

Malting winter barley (cultivar *Lord* created in Osijek Agricultural Institute) was sown at

beginning of November 2005 and harvested in term of June 21, 2006. Four areas of 0.25 m^2 (total 1.0 m^2) were harvested from each basic plot, enumerated the ears and trashed by special thrashing-machine. Grain yields calculated on 13% grain moisture and realized density basis.

Soil samples were taken before starting of the experiment (end of March 2003: mean soil

sample) and after maize harvest at end October 2005 (samples in level of basic plot). The samples were taken by auger to 30 cm of depth . For general soil test AL-extraction was used (EGNER et al., 1960). Soil reaction and organic matter were determined according to ISO (1994, 1998). Grain samples contained total thrashed grains of barley originated from 1.0 m^2 of harvested area/basic plot. These samples were used for grain quality parameters determination. Protein and starch content in grain was determined by Near Infrared spectroscopic method on Foss Tecator ("Infratec 1241 Grain Analyzer").

Weather and soil characteristics

Water shortage in October and November (38 mm precipitation compared to 146 mm for

30-year mean 1961-1990), two-fold higher precipitation in December (131mm vsv 66 mm), the colder winter (January-March: 1.5 ^oC vsv 2.6 ^oC) are main characteristics of the 2005/2006 winter barley growing season (Table 1).

By soil test (end of March 2003) acid reaction (pH in 1nKCl = 4.98), low organic matter

contents (1.86%) and moderate levels of mobile phosphorus and potassium (5.20 mg P_2O_5 and 8.13 mg K_2O 100 g/soil according the AL-method) were found. Ameliorative fertilization resulted by significant influences on increased plant available P and K. Also, it moderately influenced on soil pH increases, while humus contents were undependend on applied fertilization (Table 2).

RESULTS AND DISCUSSION

Ameliorative fertilization four years ago (spring 2003) had considerably residual effects on

grain yields of winter barley in the 2005/2006 growing season. Under standard fertilization barley yielded 5.42 t/ha. However, by application of 2500 and 3750 kg NPK 7:20:30 grain yields were increased for 6 % (5.75 t/ha) and 24 % (6.73 t/ha) respectively. However, hectolitre mass, protein and starch contents were independent on the fertilization (Table 3).

Table 1.

Weather data (Daruvar Weather Bureaue)

Precipitation (mm) and mean air-temp. (°C) – Daruvar Weather Bureau[1]										Σ	X
	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May	June	mm	°C
	The growing season 2005/2006										
mm	10	28	131	28	26	59	117	106	95	600	
°C	10.6	5.1	1.5	-1.9	1.2	5.1	11.6	15.2	19.1		7.5
	Long-term means (1961-1990)										
mm	64	82	66	55	49	58	77	86	99	636	
°C	10.9	5.8	1.4	-0.4	2.1	6.2	11.0	15.7	18.9		9.2

[1] approx. air-distance of Korenicani exp. field from Daruvar about 10 km toward nord

Table 2.

The soil test

Fertilization* (kg/ha)	pH		%	mg/100 g of soil (AL-method)	
NPK 7:20:30	H_2O	KCl	Humus	P_2O_5	K_2O
Soil status (0-30 cm depth) before starting of the experiment (March 2003)					
Mean sample	6.24	4.98	1.86	5.20	8.13
Soil status (0-30 cm depth) at end of third growing season (October 2005)*					
a) = STD	6.45	5.12	1.94	8.47	8.50
b) a + 1250	6.46	5.12	1.92	9.63	9.93
c) a + 2500	6.87	5.64	1.99	16.47	14.97
d) a + 3750	6.82	5.53	1.94	17.20	17.67
LSD5%	0.23	0.36	n.s.	28.6	24.0
Average	6.65	5.35	1.95	12.94	12.77

* STD = standard fertilization; STD fertilization of a-d treatments in 2004-2006 period.

As previous mentioned, maize was grown on this experiment for three previous growing seasons (2003-2005). Maize responded to applied fertilization by moderate yield increases up to 10% only (KOVACEVIC et al., 2007). We presume that Al-method is not suitable solution for prediction of plant available P status in this soil regarding maize growing.

Table 3.

Residual effects of fertilization by NPK 7:20:30 (April 2003) to malting barley (cultivar *Lord*) properties (the growing season 2005/2006)

Fertilization* (kg/ha) NPK 7:20:30 (April 2003)	Winter barley (Korenicani experiment 2006): Ears density per m^2, grain yield hektolitre mass (HM), protein and starch contents				
	Ears density (N/m^2)	Grain			
		Yield (t/ha)**	HM (kg)	Protein (%)	Starch (%)
a) = STD	549	5.42	71.1	10.5	53.1
b) a + 1250	545	5.37	69.6	10.3	53.0
c) a + 2500	565	5.75	70.6	10.2	53.1
d) a + 3750	548	6.73	71.2	10.2	53.1
LSD 5%	58	0.31	ns	n.s.	n.s.
Average	552	5.82	70.6	10.3	53.1

* STD = standard fertilization; STD fertilization of a-d treatments in 2004-2006 period.

** yield calculation on 13% grain moisture basis

KOVACEVIC et al. (2009) reported residual effects of ameliorative P fertilization up to 2000 kg P_2O_5/ha in form of MAP (monoammonium phosphate: 12% N + 52% P_2O_5) on yields and quality parameters of winter barley grains. Also, calcium ammonium nitrate (CAN: 27% N) was used for equalization of different levels of nitrogen added by MAP. Residual influences of ameliorative P fertilization were significant but low because yields were increased only up to 10%. Acid reaction (pH in 1n KCl: 4.26) and reduction of plant density (probably because of excess of precipitation in December) could be main responsible factors of low barley yields (t/ha: 3.02, 3.13, 3,18 and 3.33, for the control, 500, 1000 and 2000 kg P_2O_5/ha, respectively). However, hectolitre mass, 1000-grain weight, starch and protein contents in grain were independent on fertilization.

KOVACEVIC et al. (2006a) applied five rates of carbocalk (waste of sugar factory) up to

90 t/ha on Pleternica acid soil. Application of the lowest lime rate (15 t/ha) had residual effects on winter barley yield (7.50 t/ha: increasing for 30% compared to the control). By using of 45 t and more lime grain quality of malting barley decreased because of the higher protein contents.

Four rates of P in form of MAP up to 1650 kg P_2O_5/ha were applied in spring of 2003 on

Okucani hydromorphic soil moderately supplied with AL-soluble P (7.2 mg P_2O_5/100 g). In the second year of testing (the growing season 2003/2004) winter barley responded by yield increases for 20 % (3.96 t/ha: treatment 1125 kg P_2O_5/ha) and 25 % (4.15 t/ha: treatment 1625 kg P_2O_5/ha), but quality parameters (protein and starch contents in grain) were, as in our study, independent on the fertilization (KOVACEVIC et al., 2006b)

CONCLUSION

Based on the results oft his study as well our earlier investigations, ameliorative fertilization by P and K is useful soil management practice for increase yield of winter barley up to 30%. However, maize responded considerably lower because yield increases under identical soil conditions were up to 10% only.

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