

RESPONSE OF MAIZE AND SOYBEANS TO AMELIORATIVE FERTILIZATION IN BJELOVAR-BILOGORA COUNTY

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Abstract

Maize and soybeans were grown under field conditions on acid soil (pH in KCl = 3.99). The field trial was conducted in spring 2004 as follows: a = ordinary fertilization, b = a + NPK-1, c = a + NPK-2, d = a + NPK-3 and e = a + NPK-4. The fertilizer NPK 10:30:20 was source of P and K (using in amounts 416, 1249, 2082, 2916 and 3748 kg/ha, for the treatments a, b, c, d and e, respectively). Nitrogen amount was equilized for all treatments by addition of adequate quantities of CAN (calcium ammonium nitrate: 27% N) were used. The experiment was conducted in four replicates. By application of the ameliorative rates of NPK fertilizer, grain yields of maize significantly increased to level of 14% compared to standard fertilization (12.33 and 14.00 t ha⁻¹, for the control and the second rate of NPK fertilization, respectively. Only the highest rate of NPK fertilizer resulted by significant increase of protein in grain. Residual response of soybean (the growing season 2005) to the fertilization was considerably higher compared to maize, because yields of soybeans were increased up to 32%. Protein contents in soybean grain were independent on the fertilization, while oil contents were increased up to 0.66% compared to the control.

Key words: maize, soybean, yield, protein, oil, fertilization, phosphorus, potassium,

Introduction

Low levels of plant available phosphorus (P) alone or in combination with potassium (K) are limiting factor of some field crops yields, especially maize and soybean (Kovacevic and Vukadinovic, 1992, Kovacevic, 1993). Ameliorative fertilization could be solution for normalization of plant nutrition under these conditions. For this reason has been conducted the field experiment with increased rates of NPK fertilizer. Aim of this study was testing response the field crops in two years of testing (maize – soybean rotation).

Material and methods

The field experiment

The field experiment was conducted in term April 23, 2004 by application treatments as follows: a = ordinary fertilization, b = a + NPK-1, c = a + NPK-2, d = a + NPK-3 and e = a + NPK-4. The fertilizer NPK 10:30:20 was source of P and K (using in amounts 416, 1249, 2082, 2916 and 3748 kg/ha, for the treatments a, b, c, d and e, respectively). Nitrogen amount was equilized for all treatments by addition of adequate quantities of CAN (calcium ammonium nitrate: 27% N) were used. Both fertilizers are products of Petrokemija Fertilizer Factory in Kutina, Croatia. The experiment was conducted in four replicates. The experimental plot measured 77 m². Maize and soybean were sown at beginning of May by pneumatic sowing machine on the planned (theoretical) plant density (TPD: plants ha⁻¹) 64935 and 600000, for maize and soybean, respectively. Maize harvest was made manually. Four middle rows of maize were plucked. Soybean harvested area was 1.5 m². Plants of soybean were enumerated, pods were separated and harvested by special combine. Grain

yield of maize were calculated on 90% TPD and 14% grain moisture basis. Yield of soybean were calculated on TPD and 13 grain moisture basis.

Sampling and sample analyses

Two soil samples were taken before starting the experiment (April 3, 2004). The second soil sampling was made in term November 15, 2005. The samples were taken by auger to 30 cm of depth (15 individual sampling in the mean sample). The ear-leaf of maize was taken at beginning of silking (middle of July 2004; 25 leaves in the mean sample). The uppermost full-developed leaf of soybean was taken at beginning of anthesis (middle of July 2005) from each experimental plot.

Nutritional status of soil was made by extractions with AL-solution (Egner et al. 1960.) Soil reaction and organic matter were determined according to ISO (1994, 1998).

The total amount of P and K in the leaf samples was measured by the ICP-AES technique after their microwave digestion using concentrated $\text{HNO}_3 + \text{H}_2\text{O}_2$. The analyses were done in the laboratory of the Research Institute for Soil Science and Agricultural Chemistry (RISSAC), Budapest, Hungary.

Oil content in the grain was determined by nuclear magnetic resonance (NMR) spectroscopy method. Protein and starch content in the grain was determined by Near Infrared spectroscopic method on Foss Tecator ("Infratec 1241 Grain Analyzer"). These analyses were done in the Agrochemical laboratory of the Agricultural Institute in Osijek.

Weather characteristics

The growing seasons 2004 and 2005 were favourable for the spring crops growing, including maize and soybeans (Table 1). In general, low yields of maize and soybeans are in connection with water deficit, especially during July and August (Josipovic et al. 2005).

Table 1. Meteorological data (Bjelovar Weather Bureau)

Period	Bjelovar* Weather Bureau (LTM: long-term mean for 1961-1990 period)									
	Precipitation (mm)					Mean air-temperatures (°C)				
	May	June	July	Aug.	Sum	May	June	July	Aug.	Mean
2004	47	105	27	76	255	15.8	19.7	21.2	20.9	19.4
2005	81	82	123	141	427	16.6	19.7	21.4	19.0	18.4
LTM	79	96	78	82	335	15.6	18.7	20.4	19.5	18.6

* Air-distance from the experimental field: 25 km in NW direction

Soil characteristics

Acid reaction, moderate P and humus contents, as well as adequate supply of plant available potassium (Table 2) are main characteristics of Pavlovac experimental field (municipality Veliki Grdjevac, Bjelovar-Bilogora County).

Results and discussion

The NPK-fertilization resulted by significant increases of plant-available P and K status in the soil by 85% and 48% compared to the control, for P and K, respectively. Humus contents, soil reaction (pH in H_2O) and hydrolitical acidity were independent on the fertilization. Mild acidification (ph in KCl) was found under conditions of NPK-fertilization (Table 1).

By application of the ameliorative rates of NPK fertilizer, grain yields of maize significantly increased to level of 14% compared to standard fertilization (12.33 and 14.00 t ha⁻¹, for the control and the second rate of NPK fertilization, respectively). However, maize yield was significantly increased only to the second level of applied NPK fertilizer (2082 kg ha⁻¹),

while the application of the higher rates resulted by non-significant differences of maize yields. Similar trend of significance had P concentrations in maize leaves, while the leaf K was similar to applied fertilization. However, concentrations both P and K in maize grain were in close connection with the fertilization. Only the highest rate of NPK fertilizer (3748 kg ha⁻¹) resulted by significant increase of protein in grain (Table 3).

Residual response of soybean (the growing season 2005) to the fertilization was considerably higher compared to maize (the growing season 2004), because yields of soybeans were increased up to 32%. We presume that reason could be in presowing incorporation of fertilizers to the surface 15 cm of depth. By ploughing for the next growing season in autumn 2004 the fertilizer incorporated for the next crop to depth of 30 cm. However, yield differences among the ameliorative treatments were non-significant. Protein contents in soybean grain were independent on the fertilization, while oil contents were increased up to 0.66% compared to the control (Table 4).

Table 2. Properties of soil (0-30 cm)

	Soil property (0-30 cm)					
	pH		AL-method (mg/100 g)		%	HA*
	H ₂ O	KCl	P ₂ O ₅	K ₂ O	Humus	Cmol kg ⁻¹
Soil status at starting of the experiment (April 3, 2004)						
Control	5.44	3.99	9.40	17.8	1.93	
Soil status in the second year of the experiment (November 15, 2005)						
Control	4.86	3.77	11.57	17.31	2.33	6.02
NPK-1	4.90	3.43	11.70	19.57	2.22	5.86
NPK-2	4.68	3.43	12.30	18.37	2.05	5.61
NPK-3	4.35	3.38	18.60	24.24	2.16	5.97
NPK-4	4.47	3.42	21.43	25.55	2.29	5.48
LSD 5%	n.s.	0.23	0.69	0.58	n.s.	n.s.
LSD 1%		n.s.	n.s.	n.s.		

* Hydrolytical acidity

Table 3. Response of maize (the hybrid OsSK552) to NPK-fertilization

Fertilization (April 23, 2004)				Maize properties: the growing season 2004					
Treatment	kg/ha			(t/ha)**	Percent in dry matter				
	N	P ₂ O ₅	K ₂ O		Grain			Leaves***	
					Protein	P	K	P	K
Control	374	125	82	12.33	8.57	0.238	0.303	0.363	2.47
NPK-1	374	375	248	13.18	8.27	0.243	0.315	0.344	2.62
NPK-2	374	625	414	14.00	8.83	0.286	0.341	0.381	2.61
NPK-3	374	875	582	14.09	8.60	0.278	0.339	0.411	2.54
NPK-4	374	1125	746	13.73	9.33	0.302	0.363	0.412	2.56
LSD 5%				0.52	0.58	0.039	0.161	0.033	n.s.
LSD 1%				0.73	n.s.	n.s.	0.234	0.046	

* sources of nutrients: NPK 10:30:20 + CAN* (calcium ammonium nitrate: 27% N);

** yield calculation on 14% grain moisture and 90% theoretical plant density (TPD = 100% = 64 935 plants/ha; 90% = 58442 plants/ha); *** the ear-leaf at silking stage

Table 4. Residual influences of NPK-fertilization (April 23, 2004) on soybean

Fertilization (April 23, 2004)*				Soybean properties (the 2005 growing season)				
Treatment	kg/ha			(t/ha)**	Percent in dry matter			
	N	P ₂ O ₅	K ₂ O		Grain		Leaves***	
				Grain yield	Protein	Oil	P	K
Control	332	125	82	3.88	41.92	20.33	0.530	2.67
NPK-1	332	375	248	4.87	40.89	20.80	0.537	2.71
NPK-2	332	625	414	4.73	41.42	20.62	0.571	2.85
NPK-3	332	875	582	4.98	40.64	20.99	0.487	2.73
NPK-4	332	1125	746	5.14	41.94	20.73	0.501	2.69
			LSD 5%	0.72	n.s.	n.s.	n.s.	n.s.
			LSD 1%	n.s.				

* only ordinary fertilization of the treatments for 2005 (kg/ha: 80 N + 125 P₂O₅ + 82 K₂O).

** yield calculation on 13% grain moisture and plant density 600.000 plant/ha.

*** the uppermost full-developed threefoliate leaf before anthesis

Bergmann (1992) reported adequate concentrations of P and K in leaves are in range from 0.35 to 0.60 % P (both for maize and soybeans), as well as from 2.50 to 4.50 % K (maize) and from 2.5 to 3.70% K (soybean), respectively. According to these criteria nutritional status of maize and soybeans in our study were in the normal range (Tables 3 and 4).

Some nutritional disorders were observed in soybean crops in the eastern Croatia. Growth retardation and chlorosis were accompanied with the alkaline or neutral soil reaction. By the foliar diagnosis deficiency of zinc was promote by the excess of phosphorus or iron and aluminium in plants, while potassium deficiency was accompanied with the excess of magnesium uptake (Kovacevic et al.1991). Normalization of yield and soybean nutritional status were made by ameliorative fertilization with KCl as follows: yield 1.29 and 2.66 t ha⁻¹, with K:Mg relations in leaves (in chemical equivalents) 0.14 and 0.83, for the control and K fertilization (3-year menas), respectively (Kovacevic, 1992); analogical data for the next trial 1.82 and 2.72 t ha⁻¹, 0.14 and 0.36 K:Mg, respectively (Kovacevic and Grgic, 1995).

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