PHOSPHORUS AS A LIMITING FACTOR OF THE FIELD CROPS YIED UNDER CONDITIONS OF THE NORTHERN BOSNIA

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Growth retardation at early growth stage and chlorosis typical for P deficiency has been found in maize plants grown on some soils in the northern Bosnia. As chlorotic and normal plants grown on same plots, comparative analyses of chemical composition of aerial part of maize were made. In these preliminary investigations dry matter yield and P concentration of chlorotic plants were very significantly lower, while the Al and Fe concentration were higher as compared to non-chlorotic plants. Mainly low status of mobile P was found by soil testing. As affected by liming of Brcko state farm soil, yield of wheat was significantly increased 0.3 t/ha or 5% only, while yield of maize was similar to the control, although of improved P status in plants (ear-leaf of maize and flag-leaf of wheat). Low or absence effects of liming in USA were found mainly when low pH is not accompanied with high levels of mobile Al and Fe in soil. Under influences of P fertilization in Knespolje area, maize yields were increased up to 32% and 17% compared to the control, for 2004 and 2005, respectively. Also, there were tendency for increases protein and oil contents.

***Keywords**: phosphorus, soil test, maize yield.*

Soils of Bosnia and Herzegovina are mainly less favorable physical and chemical properties. Dominant soil type is pseudogley. It is estimated that about 25% of agricultural land of B&H are pseudogley or similar soils (Markovic and Supic, 2003). Acid reaction and nutritional unbalances, mainly low leveld of plant available phosphorus (P) as well as unfavorable physical properties are limiting factor of pseudogley fertility (Okiljević et al., 1997, Resulovic and Custovic, 2002, Todorovic et al., 2003). Liming and increased fertilization (mainly with P) are usualy recommendations for improvement of pseudogley soils (Kovacevic et al. 2004a, Petosic et al., 2003). Aim of this study was to give survey of some our investigations concerning soil test and response of maize to P fertilization in the northern Bosnia.

MATERIAL AND METHODS

Growth retardation of maize in the northern Bosnia Growth retardation at early growth stage and chlorosis typical for P deficiency have been found in maize plants grown on some soils in the wider part of both sides of Sava valley, in Croatia and Bosnia, respectively. As chlorotic and normal plants grown on same plots, comparative analyses of chemical composition of aerial part of maize were made (Kovacevic et al., 1988, 1992a).

Liming experiment on Brcko state farm pseudogley

The fiel experiment with liming and phosohorus applications were conducted in autumn of 1986. The experiment was conducted in duplicate and four replicates for maize-wheat rotation (the experimental plot 840 m^2 and 210 m^2, for liming and phosphorus treatment, respectively. The results were eleborated in detail by the previous studies (Kovacevic et al., 1992a, 1992b).

Recent soil sampling in area of Medjuvodje and Brekinja (municipality Kozarska Dubica)

Soil sampling was made by the auger to 30 cm of depth. Extraction with the ammonium-lactate (AL-method) was used for determinations of plant available P and K (Egner et al., 1960). Soil pH and organic matter contents were determined according ISO (1994, 1998).

The field experiment

Field experiment with increased rates of phosphorus fertilization was conducted in spring (May 7) 2004 in Potkozarje area (Knespolje, Brekinja village near Medjuvodje in the municipality Kozarska Dubica, Republic of Srpska, Bosnia and Herzegovina). They were applied four rates of P fertilizers with treatments as follows: a) ordinary fertilization (kg/ha: 200 N + 80 P_2O_5 + 120 K_2O); b) a + 500 kg P_2O_5; c) a + 1000 kg P_2O_5; and d) a + 1500 kg P_2O_5. For ordinary fertilization, KAN (calcium ammonium nitrate enriched with Mg: 27% N + 4.8% Mg) and NPK 7:20:30 were applied. The triplephoshate enriched with sulphur and zinc (45% P_2O_5 + 1,2% S + 0,06% Zn) was used for increased P fertilization. Material and methods, as well as results of the first two years of the experiment including weather data and leaf composition of maize, were in detail shown by the previous study (Komljenovic et al., 2006).

RESULTS AND DISCUSSION

Growth retardation at early growth stage and chlorosis typical for P deficiency have been found in maize plants grown on some soils in the wider part of both sides of Sava valley, in Croatia and Bosnia, respectively. As chlorotic and normal plants grown on same plots, comparative analyses of chemical composition of aerial part of maize were made (Kovacevic et al., 1988, Kovacevic and Vukadinovic 1992). Dry matter yield and P concentration of chlorotic plants were very significantly lower, while the Al and Fe concentration were higher as compared to non-chlorotic plants (Tables 1 and 2).

As affected by liming yield of wheat was significantly increased 0.3 t ha^{-1} or 5% only, while yield of maize was similar to the control, although of improved P status in plants (ear-leaf of maize and flag-leaf of wheat). Also, liming influenced significantly on increases of Ca and Mg, as well decrease of K in maize leaves. In general, influences of liming on nutritional status of wheat leaves were lower in

comparison with maize (Table 3). Effects of liming under conditions of USA are also different. Low or absence effects of liming were found mainly when low pH is not accompanied with high levels of mobile Al and Fe in soil (Mc Lean and Brown, 1984).

Table 1

Characteristics of aerial part of maize at early growth stage (DMY = dry matter yield) and P-deficient soils of Nova Topola state farm (Kovacevic and Vukadinovic, 1992)

Plant status	Top of maize at early growth stage (June 1986)						Soil properties		
	DMY	% in DM		mg/ kg on DM basis			pH	mg/100 g	
	g/ plant	P	K	Al	Fe	Zn	KCl	P_2O_5	K_2O
Chlorotic*	2.78	0.29	4.93	3818	2925	48	4.07	8.3	21.0
Normal*	18.84	0.46	5.41	470	410	36	4.84	8.0	20.0

*means of four samples; P and K in soil were determined by AL-method (Egner et al. 1960)

Table 2

Properties of maize at 6-9 leaves stage (June 1986) on P-deficient soils of Brcko area (Kovacevic et al., 1988)

Sam-ple	Aerial part of maize at 6-9 leaves stage (June 1986): dry matter yield (DMY), plant height (PH) and P, Fe and Al status (on DM basis)									
	Chlorotic maize					Normal maize				
	g/ plant	cm	%	mg/ kg		g/ plant	cm	%	mg kg^{-1}	
	DMY	PH	P	Fe	Al	DMY	PH	P	Fe	Al
	Arable lands of former state farm Brcko (means of four samples)									
1	2.04	26	0.60	1260	2150	11.00	51	0.46	440	550
2	1.52	24	0.32	1020	1671	8.79	53	0.53	420	666
3	1.17	20	0.18	700	1891	9.03	56	0.23	260	226
4	1.72	24	0.39	980	1929	11.49	51	0.53	320	395
Mean	1.61	24	0.37	990	1910	10.08	53	0.43	360	459

* the samples of chlorotic and normal maize of same number were taken from the same plot

Table 3

Residual effects of liming and phosphatization (superphosphate: 42% P_2O_5) in autumn 1986 on maize nad wheat status on Brcko state farm pseudogley soil

P_2O_5 kg /ha	Grain yield (t ha^{-1}) and nutritional status (% on dry matter basis) of ear-leaf at silking (maize) and flag-leaf at heading stage (wheat)									
	Maize (Kovacevic et al., 1992a)					Wheat (Kovacevic et al., 1992b)				
	t/ha	P	K	Ca	Mg	t/ ha	P	K	Ca	Mg
	The control									
0	3.96	0.24	3.29	0.99	0.34	5.48	0.24	3.35	0.38	0.28
1350	3.78	0.26	3.24	0.88	0.38	5.82	0.30	3.46	0.52	0.29
	Liming with calcite (32 t/ha)									
0	4.00	0.31	2.50	1.59	0.48	5.77	0.33	3.21	0.44	0.26
1350	3.84	0.31	2.16	1.53	0.50	6.01	0.45	3.89	0.43	0.30
LSD 5%	n.s.					0.23				

Markovic and Supic (2003) found in pseudoglay of the northern Bosnia very acid soil reaction, plant available phosphorus and potassium as well. However, quantities of mobile aluminium were high(above 10 mg/100 g) and they are toxic for the field crops (Table 4).

Table 4

Chemical characteristics of theGradiska municipality pseudoglay profile under pasture as a native vegetation (Markovic and Supic, 2003)

Soil depth (cm)	% Humus	pH		mg/100 g (AL-method)		Mobile Al^{3+}	Adsorption complex meq/100g			%
		H_2O	KCl	P_2O_5	K_2O		H	S	T	V
5-15	1.55	5.21	4.03	1.90	4.80	12.78	10.56	7.96	18.52	42.97
25-35	0.15	5.33	3.89	0.80	4.70	22.23	8.22	10.48	18.70	56.04
45-55	0.10	5.56	3.84	0.20	6.30	30.78	9.43	16.64	26.70	63.84

In our recent investigations of soil nutritional status, mainly low levels of plant available P and acid reaction were found. Under these conditions could be useful liming and increased P fertilization. Potassium availability is mainly in normal ranges (Table 5).

Table 5

Results of recent soil testing (0-30 cm depth) in area of the northern Bosnia

Soil sample	pH		Percent		mg/100 g of soil		meq/100 g Hy
	H_2O	KCl	Humus	$CaCO_3$	P_2O_5	K_2O	
	Medjuvodje and Brekinja area (municipality Kozarska Dubica)						
1	7.65	6.90	4.08	8.04	11.3	31.06	0
2	7.92	7.11	4.87	12.73	9.3	21.13	0
3	8.02	7.32	6.93	9.76	11.0	30.19	0
4	7.09	6.43	4.49	1.27	1.8	11.30	0
5	5.06	4.34	4.74	0	2.0	9.20	5.73
6	5.72	4.59	4.59	0	6.2	10.02	4.94
7	5.93	4.74	4.24	0	5.3	16.97	4.29
8	5.60	4.32	4.58	0	5.6	22.89	6.04
	Area of Gradiska municipality						
1	5.83	4.76	1.91	0	4.9	18.9	-
2	6.30	4.93	3.2	0	4.0	10.1	-
3	5.35	4.41	2.1	0	2.0	9.1	-

Table 6

Influences of P fertilization (spring 2004) on yield and quality of maize grain (Komljenovic et al., 2006)

P fertiliz*ati*on (kg P_2O_5 /ha), yield (t/ha), protein, starch and oil contents (% in dry matter)									
The growing season 2004					The growing season 2005*				
P_2O_5 kg/ha	t/ha Yield	% in maize grain Prot.	Starch	Oil	P_2O_5 kg/ha	t/ha Yield	% in maize grain Prot.	Starch	Oil
80	7.90	9.65	69.6	4.38	80	7.27	7.78	71.3	3.54
580	9.18	9.60	70.0	4.56	80	8.53	8.29	71.3	3.45
1080	9.85	9.80	69.9	4.66	80	8.38	8.89	71.2	3.51
1580	10.40	9.95	69.6	4.70	80	8.42	7.85	71.4	3.55
Analyses of variance (LSD-values)					Analyses of variance (LSD-values)				
5%	0.37	n.s.	n.s.	n.s.		0.29	n.s.	n.s.	n.s.
1%	0.53					0.42			

* residual effects of the ameliorative P fertilization

Under influences of P fertilization maize yields were increased up to 32% and 17% compared to the control, for 2004 and 2005, respectively. Also, there were tendency for increases protein and oil contents (Table 6). P fertilization significantly influenced on decreases of the leaf Mg by 38%, Mn by 30%, Zn by 48% and Mo by 53% compared to the control (mg kg^{-1} on the control: 1526 Mg, 44.3 Mn, 45.2 Zn, 2.62 Mo) and increases of the leaf Sr by 31% and Cd by 84% (mg kg^{-1} on the control: 62.3 Sr and 0.25 Cd), while differences of the remaining measurable elements (P, K, S, Fe, Cu, Ni, Cr, B, Ba, Na, and Al) were non-significant. Also, the leaf As, Hg and Se concentrations were under detectable levels of the method (Komljenovic et al., 2006).

BIBLIOGRAPHY

1. Egner, H., Riehm, H., Domingo, W.R.,1960 - *Untersuchungen uber die chemische Bodenanalyse als Grundlage fur die Beurteilung des Nahrstoffzustandes der Boden II. Chemische Extractionsmethoden zuPhosphor- und Kaliumbestimmung.* K. Lantbr. Hogsk. Annlr. W.R. ,26, p.199-215.
2. ISO 1994 - *Soil quality. Determination of pH.* ISO 10390.
3. ISO 1998 - *Soil quality. Determination of organic carbon by sulfochromic oxidation*". ISO14235.
4. Kovacevic V., Banaj D., Brkic I., Antunovic M., Petosic D. 2004 - *Fertilization impacts on the yield and nutritional status of maize (Zea mays L.).* Cereal Research Communications 32 (3) 403-410.
5. Kovacevic, V., Bertic, B., Josipovic, M. 1992a- *Kalcizacija i fosfatizacija kao faktori proizvodnje kukuruza u istocnoj bosanskoj Posavini (Liming and phosphatization as factors affecting the maize production in the eastern Posavina of Bosnia).* Znan. prak. poljopr. tehnol. Vol. 22 , No. 2, pp.331-342.
6. Kovacevic V., Vukadinovic V., 1992- *Phosphorus deficiency in maize (Zea mays L. plants used for seed production.* Fourth International IMPHOS (Institut Mondial du Phosphate) Conference, September 8-11, Ghent, Belgium. pp. 688-690.
7. Kovacevic V., Vukadinovic V., Bertic B. ,1988- *Excessive iron and aluminium uptake and nutritional stress in corn (Zea mays L.) plants*. Journal of Plant Nutrition, vol.11, No 6-11, pp.1263-1272.
8. Kovačević V., Žugec I., Jurić I., 1992b- *Reakcija pšenice na kalcizacju i fosfatizaciju u istočnoj bosanskoj Posavini (Response of wheat to liming and phosphatization in the eastern part of Bosnian Posavina)* Znan. prak. poljopr. tehnol. Vol. 22, No 2, pp.319-330. Osijek.
9. Markovic M. and Supic D., 2003 - *Osobine pseudogleja na području Gradiške s prijedlogom meliorativnih mjera*. Agroznanje, vol. IV, No 1, pp. 142-154.
10. Mc Lean and Brown J.C., 1984- *Crop response to lime in the Midwesstern United States.* In: Soil Acidity and Liming - Agronomy Monograph No 12 (Adam F. Editor), ASA-CSSA-SSSA, Madison, Wisconsin, pp 267-303.
11. Okiljevic V., Predic T., Lukic R., Markovic M. ,1997 - *Poljoprivredno zemljište Republike Srpske*. Agroznanje, vol. 1, No. 1, pp.15-23, Banka Luka.
12. Petosic D., Kovacevic V., Josipovic M., 2003- *Phosphorus availability in hydromorphic soils oh Eastern Croatia.* Plant, Soil and Environment, vol. 49, No.9, pp. 394-401.
13. Resulović H., Čustović H., 2002 - *Pedologija. Opšti dio (knjiga 1).* Univerzitet u Sarajevu.
14. Todorović J., Lazić B., Komljenović I., 2003 - *Ratarsko-povrtarski priručnik*. Grafomark, Laktaši, RS, BiH.