AMELIORATIVE PK-FERTILIZATION AND LIMING IMPACTS ON SOIL STATUS

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Abstract: Five steps of PK-fertilization were applied in spring of 2004 on Pavlovac acid (pH_{KCl} = 3.99) soil (Bjelovar-Bilogora County) moderately supplied with phosphorus (available P_2O_5 according AL-method: 9.40 mg $100g^{-1}$) in amounts as follows: a = ordinary fertilization (kg ha^{-1}: 125 P_2O_5 + 82 K_2O), 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^{-1}, for the treatments a, b, c, d and e, respectively). Nitrogen amount (375 kg N ha^{-1}) was equilized for all five treatments by addition of correspondingle quantities of CAN (calcium ammonium nitrate: 27% N). The experiment was conducted in four replicates (basic plot 77 m^2). Subsequent intervention in the experiment was liming (10 tones ha^{-1}) of half of the area with granulated fertdolomite containing 24.0% Ca + 16.0% MgO + 3.0% N + 2.5% P_2O_5 + 3.0% K_2O. Remaining two replicates have been used as control. At third soil sampling two soil samples were taken from each basic plot. Soil sampling (0-30 cm) were made in three terms as follows: at start of the trial (April 3, 2004), November 15, 2005 and September 3, 2009. According to the results of AL-method, the five steps of PK fertilization significantly increased the average content of soluble phosphorus and potassium in soil. The liming had a similar significant effect on the available phosphorus but liming caused insignificant decrease in available potassium. Hence, mineral fertilization and liming simultaneously increased available phosphorus, but effects on the potassium were opposite. Also, mineral fertilization and liming had a different impact on soil pH since mineral fertilization significantly decreased and liming significantly increased soil pH.

Keywords: fertilization, liming, pH, phosphorus, potassium

Introduction

Low levels of plant available phosphorus alone or in combination with potassium are limiting factors of some field crops yields (Kovacevic and Vukadinovic, 1992). Also, there are examples where low levels of these two nutrient were in combination with low soil pH reaction (acidic soils) and these soils are not common for efficient crop production. Ameliorative fertilization and application of lime could be solution for normalization of plant nutrition under that conditions (Kovacevic et al., 2007). The influence of fertilization and liming on soil properties were investigated by numerous authors (Bowszys et al., 2005; Hughes et al., 2004; Jovanovic et al., 2006; Loncaric et al., 2007; Rastija et al., 2008). The aim of this paper was to determine the effects of different rates of mineral fertilizer and liming as subsequent intervention on the changes in the soil chemical properties.

Materials and methods

The field experiment

Five steps of PK-fertilization were applied in April of 2004 on Pavlovac acid (pH in KCl = 3.99) soil (Bjelovar-Bilogora County) moderately supplied with phosphorus (available P_2O_5 according AL-method: 9.40 mg $100g^{-1}$) in amounts as follows: a = ordinary fertilization (kg ha^{-1}: 125 P_2O_5 + 82 K_2O), b = a + NPK-1, c = a + NPK-2, d =

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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^{-1}, for the treatments a, b, c, d and e, respectively. Nitrogen amount (375 kg N ha^{-1}) 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 m^2. Soil sampling (taking by auger to 0-30 cm of depth) were made in three terms as follows: at starting of the trial (April 3, 2004), November 15, 2005 and September 3, 2009. Crop sequence since 2004 has been as follows: maize (2004), soybean (2005), maize (2006), wheat (2007), maize (2008), and maize (2009). Subsequent intervention in the experiment was liming (10 tones ha^{-1}) of half of the area (the third and fourth replicates) with granulated fertdolomite (product of Petrokemija Fertilizer Factory in Kutina, Croatia) containing 24.0% Ca + 16.0% MgO + 3.0% N + 2.5% P_2O_5 + 3.0% K_2O. Remaining two replicates have been used as control. At third soil sampling two soil samples were taken from each basic plot.

Soil characteristics

Nutritional status of soil was controlled by phosphorus and potassium extractions using AL-method (Egner et al., 1960), which is the most frequently used method in Croatia. Soil pH reaction was analyzed according to standard methods (ISO, 1994) in water and M KCl solution. Soil organic matter was determined by sulfochromic oxidation (ISO, 1998). Also, hydrolytic acidity was determined by extraction of soil samples using Na-acetate solution.

Results and discussion

Investigated soils were very acid (pH_{KCl} 3,99) and according to AL method showed very low phosphorus and moderate potassium content. Organic matter was 1.93 % and hidrolitycal acidity 6.92 cmol kg^{-1} (Table 1). The five steps of PK fertilization significantly increased average of available phosphorus and potassium in soil. Compare to control, phosphorus availability increased from 9.40 to 21.43 mg $100g^{-1}$ and potassium from 17.8 to 25.55 mg $100g^{-1}$ (highest NPK treatments).

The soil pH (pH_{KCl}) was slightly decreased by mineral fertilization from 3.99 to 3.38. At the same time mineral fertilization had no significant influence on soil organic matter and hydrolytic acidity (Table 1). The resembling results were confirmed by Rastija et al. (2006).

The liming had a similar significant effect on the available phosphorus and the content of available phosphorus were higher under liming conditions (16.00 mg $100g^{-1}$) than on control plots (9.40 mg $100g^{-1}$). Similar effects regarding available phosphorus were observed by Loncaric et al. (2007) and Rastija et al. (2008). However, insignificant decreased of available potassium was found under liming conditions (Table 1). Liming is known to affect the availability of several plant nutrients but the extent of the lime effect is usually difficult to quantify (Curtin and Smille, 1986). The major role of liming was to overcome soil acidity and application of lime in this trial increased soil pH from pH_{KCl} 3.9 to pH_{KCl} 4.55. As it was expected, the hydrolytic acidity was lower after liming and decreased from 6.92 to 4.88 cmol kg^{-1}. Mineral fertilization and liming simultaneously increased available phosphorus up to 18.70 mg $100g^{-1}$, but effects on the potassium were opposite. In fact, slightly decreasing of available potassium was found after liming and fertilization (15.6 mg $100g^{-1}$) comparing to control treatment without liming and fertilization (17.08 mg $100g^{-1}$). The decrease of soluble AL-K content might be the result of Ca – K cationantagonism in soil. Also, mineral fertilization in combination with liming had a positive impact on soil pH and pH_{KCl} increased up to 4,67. Organic matter content was independent on the fertilization and liming treatments.

Table 1. Soil chemical characteristics before and after trial

	Soil property (0-30 cm)											
	pH				AL-method (mg 100 g^{-1})				%		Hydrolytic acidity*	
	H_2O		KCl		P_2O_5		K_2O		Humus		cmol kg^{-1}	
	The first soil sampling (before starting of the experiment: April 3, 2004)											
Control	5.44		3.99		9.40		17.8		1.93		6.92	
	The second soil sampling (November 15, 2005) – Rastija et al., (2006)											
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 0.05	n.s.		0.23		0.69		0.58		n.s.		n.s.	
LSD 0.01			n.s.		n.s.		n.s.					
	Subsequent intervention on the NPK-fertilization treatments: liming of half of the experiment area (Noveber 13, 2007) with granulated Fertdolomite (10 tons ha^{-1}) containing 24.0% Ca + 16.0% MgO + 3.0% N + 2.5% P_2O_5 + 3.0% K_2O											
	The third soil sampling (Sept. 3, 2009): effects of liming (A1= control; A2 = Fertdolomite 10 tons ha^{-1}), NPK-fertilization (five steps of B) and their interactions											
	Effects of liming (the factor A)											
Control (A1)	4.94		3.81		14.47		19.00		1.98		6.92	
Lime (A2)	5.61		4.55		16.00		17.80		1.98		4.88	
	Effects of NPK-fertilization (the factor B)											
Control (B1)	5.30		4.12		11.93		15.73		1.94		5.84	
NPK-1 (B2)	5.17		4.10		12.33		17.13		2.00		5.87	
NPK-2 (B3)	5.34		4.28		16.13		18.73		1.98		5.60	
NPK-3 (B4)	5.28		4.18		16.67		20.10		1.98		6.02	
NPK-4 (B5)	5.30		4.21		19.10		20.30		2.01		6.16	
	Effects of the AB interaction											
	A1	A2	A1	A2	A1	A2	A1	A2	A1	A2	A1	A2
Control (B1)	4.92	5.67	3.80	4.44	11.1	12.7	15.6	15.7	1.89	2.00	6.82	4.85
NPK-1 (B2)	4.97	5.36	3.87	4.32	11.5	13.2	17.7	16.6	2.09	1.91	6.54	5.20
NPK-2 (B3)	4.94	5.76	3.80	4.77	14.4	17.8	19.7	17.8	1.95	2.00	6.56	4.64
NPK-3 (B4)	4.98	5.58	3.81	4.55	16.6	16.719.5	21.4	18.8	1.95	2.01	7.12	4.92
NPK-4 (B5)	4.90	5.69	3.75	4.67	18.7		20.5	20.1	2.03	1.99	7.57	4.78
	The third soil sampling (Sept. 3, 2009): Statistical analyses (ns = non-significant)											
LSD -test	0.05	0.01	0.05	0.01	0.05	0.01	0.05	0.01	0.05	0.01	0.05	0.01
A	0.11	0.24	0.10	0.23	1.78	ns	ns		ns		0.52	1.20
B	ns		ns		1.72	2.37	1.61	2.22	ns		0.23	0.31
AB	ns				ns		ns		ns		0.32	0.44

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Conclusions

Resulted showed that five steps of PK fertilization significantly increased average content of available phosphorus and potassium in soil. The liming had a similar significant effect on the available phosphorus but at the same time insignificant decreased available potassium. Hence, mineral fertilization and liming simultaneously increased available phosphorus, but effects on the potassium were opposite. Also, mineral fertilization and liming had a different impact on soil pH since mineral fertilization significantly decreased and liming significantly increased soil pH. Liming and mineral fertilization had no influence on soil organic matter.

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