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EFFECTS OF LONG-TERM K FERTILIZATION AND LIMING ON 0.01M $CaCl_2$ EXTRACTABLE K CONTENT OF A HAPLIC PHAEOSEM SOIL

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ABSTRACT. Effects of regular K fertilization and liming on the easily available K content of a *Haplic phaeosem* soil determined in 0.01 M CaCl2 were examined in the B1740 type of the National Uniformed Long-Term Fertilization Experiment at Karcag. Close correlation (r=0.95) were found between the 0.01M $CaCl_2$ and ammonium lactate acetic acid (AL; traditional method of Hungary) extractable K contents of soils. K fertilization increased significantly the amount of 0.01M $CaCl_2$ extractable K. Liming decreased the amount of $CaCl_2$-K. We can explain this by the changing of the rate of exchangeable K compared to exchangeable bases. $CaCl_2$ extractable K was in good agreement with the exchangeable K content of soil and the agronomic K balance. We can conclude that $CaCl_2$ method is suitable for the precise estimation of nutrient requirements.

Keywords: long-term experiment, extractable K, *Haplic phaeosem* soil

INTRODUCTION

The environmentally conscious and site-specific nutrient management is an important objective of the advanced agriculture. Therefore we have to know exactly the easily available nutrient content of soil. The traditional extractant of Hungary is the ammonium lactate acetic acid (AL) (Egnér et al., 1960). On the bases of the decades of experiences many researcher suggested the standardization of new methods (LOCH et al., 2005; Fekete et al., 1983; Marth, 1990).

The 0.01 mol CaCl2 extractant is also suitable for characterizing K-supply of soil. This universal extractant is known all over Europe since the 90’s. The method’s advantages were summarized by Houba et al. (1991) and Loch (2006) as follows: dilute salt solution has moderate solving and ion exchanging effects; the Ca content of the extractant is similar to the Ca concentration of soil solutions; the extracted solution can be filtered easily; several nutrients (N, P, K) and certain microelements are well measurable; easily soluble and oxidizable organic N, P and S forms are also measurable in the extraction.

In our previous researches we found that the K content, extracted by AL is depends on the soil texture and pH of soil, while the CaCl2-K didn’t change as an effect of soil parameters (Bertáné et al., 2009).

The aims of the presented research were to examine the effects of regular K fertilization and liming on the amounts of AL-K, CaCl2-K and extractable K. In addition the study focuses on the relations among AL-K, CaCl2-K and extractable K.

MATERIALS AND METHODS

The B17 variant of the National Long-Term Fertilization Experiments was established in the autumn of 1967 by uniform directives at the trial site of the Karcag Research Institute. The arrangement of the small-plot field experiment is split-plot with four replications. The sequence in the crop rotation was the same in all of the ten completed cycles: winter wheat–maize–maize–winter wheat. The fertilization treatments are summarized in Table 1. As the data show, the number of treatments is altogether twenty: combinations of 3 N-, 3 P-, and 2 K-doses, completed by the control treatment and by a N4P3K2 treatment with increased doses.

The full PK-doses were distributed in autumn. After the harvest of the winter wheat grown in the 20th and 32nd years of the experiment 14.5 and 11.05 t ha-1 of lime was used on the plots of replications I and III, respectively.

The soil of the experimental site is a Luvic Phaeosem solonetzic in the deeper layers. The parent material is infusion loess with loamy clay texture. The topsoil is slightly acidic; below 40 cm the soil is calcareous. The soil is moderately supplied with N, poorly with P and moderately with K.

Soil samples were taken in 2007 from 20 points of each plot, from the 0–20 cm soil layer, after the harvest of winter wheat. The K contents of the soil samples were measured in 0.01 mol CaCl2 extractant (Houba et al., 1990) with a flame emission spectrophotometer at the laboratory of the Department of Agricultural Chemistry and Soil Science.

All statistical analyses (regression analyses, variance analyses) were performed with SPSS (version 13). Significant differences were examined by One Way Anova and LSD post hoc tests.

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Table 1

Fertilizer doses applied in the B17 experiment (kg•ha-1) (Karcag, 1971–2007)

Treatments	Cycle 2–5			Cycle 6–10		
	N	P	K	N	P	K*
$N_0P_0K_0$	–	–	–	–	–	–
$N_1P_0K_0$	50	–	–	100	–	–
$N_1P_1K_0$	50	21.8	–	100	26.2	–
$N_1P_2K_0$	50	43.6	–	100	52.3	–
$N_2P_0K_0$	100	–	–	150	–	–
$N_2P_1K_0$	100	21.8	–	150	26.2	–
$N_2P_2K_0$	100	43.6	–	150	52.3	–
$N_3P_0K_0$	150	–	–	200	–	–
$N_3P_1K_0$	150	21.8	–	200	26.2	–
$N_3P_2K_0$	150	43.6	–	200	52.3	–
$N_1P_0K_1$	50	–	83	100	–	83/166
$N_1P_1K_1$	50	21.8	83	100	26.2	83/166
$N_1P_2K_1$	50	43.6	83	100	52.3	83/166
$N_2P_0K_1$	100	–	83	150	–	83/166
$N_2P_1K_1$	100	21.8	83	150	26.2	83/166
$N_2P_2K_1$	100	43.6	83	150	52.3	83/166
$N_3P_0K_1$	150	–	83	200	–	83/166
$N_3P_1K_1$	150	21.8	83	200	26.2	83/166
$N_3P_2K_1$	150	43.6	83	200	52.3	83/166
$N_4P_3K_2$	200	65.4	83	250	78.5	83/207

** 83 kg•ha-1 for winter wheat; 166 and 207 kg•ha-1 for maize*

RESULTS AND DISCUSSIONS

During our research work the relationship between AL and 0.01 mol CaCl2 extractable K content of the soil samples were studied (Fig.1).

Close correlation (R2=0,91; r=0.95) was found between the amount of AL-K and CaCl2-K. According to our previous researches soil texture is the most important factor modifying the closeness of the correlation between AL-K and CaCl2-K, because AL-K depends on this significantly. Presumably AL is capable to exchange a part of bounded K, which is not available for plants so it characterizes K-reserves as well. The reason of the close relation between extracted K contents on studied soil samples is in one hand that the important soil properties (texture, pH, carbonate content, humus content) are the same in all samples (samples originated from the same soil type, with different fertilization rates), and in the other hand the dominant clay mineral in clay fraction is illite which means that K-fixation is not typical in this soil.

We studied the effect of liming and long-term K fertilization on the AL and 0.01 mol CaCl2 extractable K content of the soil, exchangeable K (mg ekv 100g-1) and K% (K Ca+Mg+K+Na-1 mg ekv 100g-1) (Table 2). The treatments had a significant effect on the amounts of extractable and exchangeable K. K fertilization increased significantly the amount of all studied parameter. Liming without K fertilization increased significantly the amount of AL-K and exchangeable K comparing to the K0 treatment, but it didn't cause significant differences in case of applying K1 fertilizer rate. By contrast the CaCl2-K content of the soil and K% decreased significantly as an effect of liming. We can explain this with the increasing of exchangeable Ca content of soils, which causes the changing of the ratio of exchangeable bases.

It can be stated that while AL-K characterize the exchangeable K content of soil, the changeing of K% reflected in the CaCl2-K.

Relationships between exchangeable K, K% and K content of soil extracted by AL and 0.01mol $CaCl_2$ were studied with regression analysis (Fig. 2, Fig. 3). We found significant, close correlations between the soil parameters:

- Exchangeable K – AL-K (R2=0.87; r=0.93)
- Exchangeable K – CaCl2-K (R2=0.81; r=0.9)
- K% – AL-K (R2=0.74; r=0.86)
- K% – CaCl2-K (R2=0.88; r=0.94)

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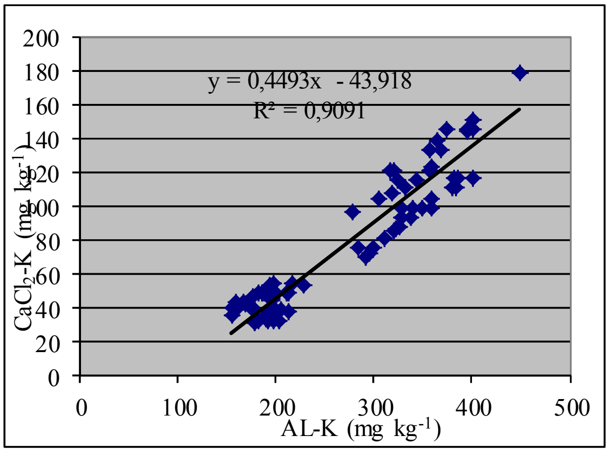

Fig. 1 Relationship between the amount of AL-K and $CaCl_2$-K

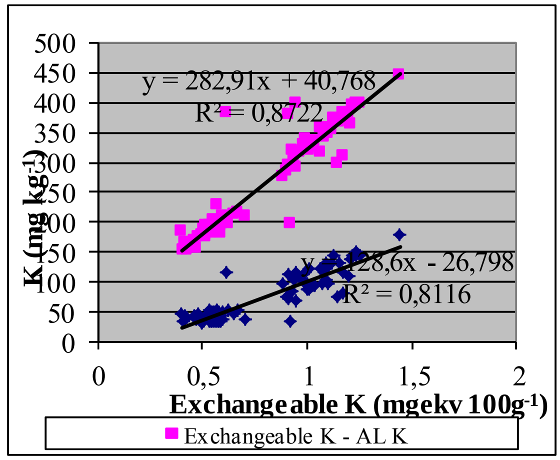

Fig. 2 Relationships between exchangeable K and K content of soil extracted by AL and 0.01 mol CaCl2

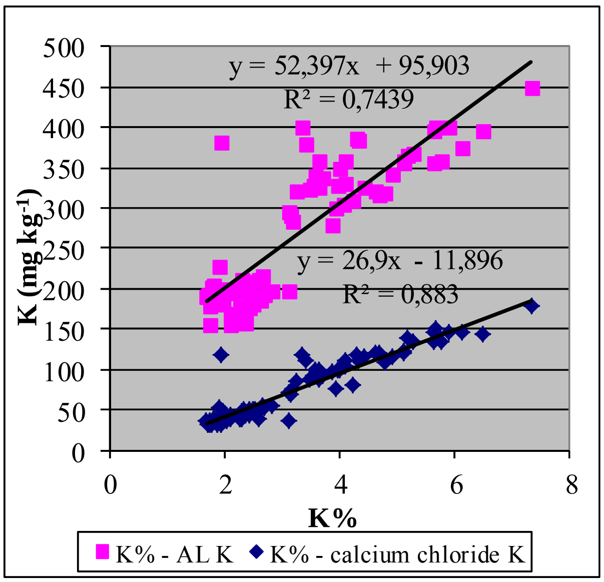

Fig. 3 Relationships between K% and K content of soil extracted by AL and 0.01 mol CaCl2

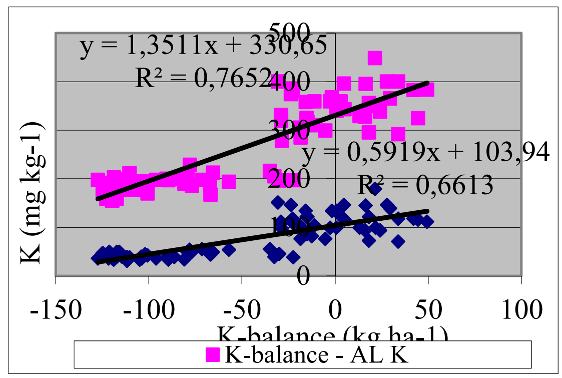

Fig. 4 Relationships between K-balance and K content of soil extracted by AL and 0.01 mol CaCl2

Table 2

The effect of liming and long-term K fertilization on the AL and 0.01 mol $CaCl_2$ extractable K content of the soil, exchangeable K and K%

Treatment	AL-K (mg kg^{-1})	SD*	$CaCl_2$-K (mg kg^{-1})	SD*	Exchangeable K (mg ekv $100g^{-1}$)	SD*	K %**	SD*
K_0	182.1	a	45.8	a	0.52	a	2.34	a
K_0 with liming	197.4	b	37.0	b	0.59	b	2.00	b
K_1	355.7	c	129.4	c	1.11	c	5.24	c
K_1 with liming	339.2	c	94.8	d	1.01	c	3.60	d
Total	268.6		76.8		0.81		3.30	

**Significant difference: Means designated by the same letter were not significantly different at P = 5% level.*
***K Ca+Mg+K+Na^{-1} (mg ekv $100g^{-1}$)*

It means that the amounts of K extracted by the two methods depend on the amount of exchangeable K and on the ratio of it compared to the amount of exchangeable bases. The results of regression analysis confirmed that the CaCl2-K characterize the relative amount of exchangeable K opposite of AL-K which is related to the absolute amount of exchangeable K.

We studied the relationship between the agronomic K-balance (fertilizer K – K uptake of plants) and the K content of soil extracted by AL and 0.01 mol CaCl2 (Fig. 4). Significant close correlations (R^2=0.77, r=0.88; R^2=0.66, r=0.81) were found between the parameters. It means that the two extractant are suitable for characterizing the K-supply of the soil.

CONCLUSIONS

The results of regression analyses confirmed that there is a close correlation (r=0.95) between the amount of AL-K and CaCl2-K in the same soil type. This result is in accordance with our previous researches.

It can be stated that both method could describe the K-supply, because they are in good agreement with exchangeable K and K-balance.

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