Studies on the Available K Content of Different Soils at Constant Moisture

K. SÁRDI and T. NÉMETH

Pannon University of Agricultural Sciences, Keszthely and Research Institute for Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences, Budapest

Introduction

For a wider understanding of the dynamics of potassium in different soil types, one must take into consideration the clay minerals having specific K^+ binding sites. The weathering, wetting and drying of these clay minerals, as well as other soil and plant factors affecting K availability in soils, are of primary importance (GRIMME et al., 1971; VAN DIEST, 1979; TISDALE et al., 1990). In order to maintain soil fertility during intensive cropping, field studies are required on potassium mobility, the supplying capacity of different soils and yield responses to K fertilization. For estimating the actual K status of a soil, easily exchangeable forms are to be determined. NH_4 salts are commonly used as extractants in buffered or neutral solutions (EGNER et al., 1960; WANASURIA et al., 1981; BLUM, 1983).

The potassium exchangeable by these salts is mostly the fraction absorbed on clay minerals and organic matter, and is considered by many authors as the plant available amount (MENGEL, 1982; MENGEL & KIRKBY, 1987; NOVOZAMSKI & HOUBA, 1987).

However, none of the methods used can give perfect information on the availability during the growing period of crops. For an adequate description, a detailed examination of different extractable K forms and reserves is necessary (QUÉMENER, 1979; GRIMME & NÉMETH, 1979).

Soils in Hungary show considerable differences in their clay mineral composition which has a marked influence on their potassium transformations.

Long-term multilocation fertilizer field trials in Hungary - representing different agro-ecological regions of the country - may provide a great opportunity for studying the potassium dynamics between soils, crops and fertilizers (SÁRDI & DEBRECZENI, 1992).

An incubation experiment was carried out using the soil samples taken from several sites of these field fertilization trials. The potassium nutrient content

($AL\text{-}K_2O$) of soils after long-term K fertilization represented three different levels. The objective of this experiment was to study:

a) Changes in the exchangeable potassium content in soils as a result of incubation; maintaining the constant moisture favourable for plant uptake;

b) the effect of a high constant dose of K fertilizer on the exchangeable K amounts of different soil types and on K levels;

c) the rates of recovery by two extractants after four weeks of incubation and a comparison of the two extraction methods.

Materials and Methods

The incubation experiment was carried out in pots using 100 g of air-dried soil in 4 replications.

Soil samples were taken from 9 sites of the national long-term multilocation field experiments:

1. Kompolt (KO) - Haplic Phaeosem
2. Karcag (KA) - Luvic Chernozem
3. Hajdúböszörmény (HB) - Luvic Phaeosem
4. Keszthely (KE) - Eutric Cambisol
5. Iregszemcse (IR) - Calcaric Phaeosem
6. Mosonmagyaróvár (MO) - Calcaric Fluvisol
7. Putnok (PU) - Ochric Luvisol
8. Bicsérd (BD) - Luvic Phaeosem
9. Nagyhörcsök (NH) - Calcaric Phaeosem.

The physico-chemical characteristics of the soils are shown in Tables 1 and 2.

Table 1

Some physico-chemical characteristics of the experimental soils

Soil*	Clay content %	Illite content %	$CaCO_3$ content %	Humus content %	pH (KCl)		
					000	441	442
1. KO	38	27	-	2.8	4.56	4.43	4.21
2. KA	37	56	-	2.9	4.56	4.30	4.36
3. HB	30	29	-	3.8	6.43	6.55	6.68
4. KE	17	59	-	1.9	5.92	5.52	5.64
5. IR	18	50	6.2	2.3	7.21	7.17	7.21
6. MO	15	48	19.5	2.7	7.27	7.27	7.27
7. PU	24	33	-	1.6	4.46	4.30	4.29
8. BD	27	45	-	1.9	5.61	5.46	5.27
9. NH	23		5.5	2.9	7.26	7.19	7.19

*For abbreviations: See Materials and methods

Table 2

Exchangeable potassium content of soils, mg K_2O/kg soil

Soil	AL-soluble K_2O			NH_4-acetate exchangeable K_2O		
	000	441	442	000	441	442
1. KO	183 poor	268 fair	357 excessive	230	252	383
2. KA	267 medium	339 fair	465 excessive	278	263	545
3. HB	108 very poor	136 very poor	174 poor	158	167	200
4. KE	111 very poor	149 poor	193 fair	155	168	208
5. IR	149 very poor	185 poor	271 fair	159	183	262
6. MO	91 very poor	122 very poor	169 poor	144	153	179
7. PU	121 poor	183 fair	260 excessive	141	199	264
8. BD	163 poor	223 medium	290 good	174	234	289
9. NH	148 very poor	204 medium	312 good	150	217	335

The long-term fertilizer rates applied for 20 years were:

Code No.	N	P_2O_5	K_2O
	kg/ha/year		
000	0	0	0
441	200	200	100
442	200	200	200

The plots were kept at constant temperature (25 °C ± 0.2 °C) and constant moisture (70% of field capacity for the experimental soils) for 4 weeks. To ensure aeration, there was a layer of river gravel under the soil and a glass pipe was placed in it.

At the start of the experiment a standard amount of K (1000 mg K_2O/kg soil) was applied using KCl fertilizer dissolved in water, to study possible changes in the exchangeable K levels in the soils. The exchangeable K amounts ("plant-available" potassium) in the soils were determined:

- at the start of the experiment (S);
- after 28 days of incubation (I);
- after the addition of 1000 mg K_2O/kg soil and 28 days of incubation (K).

The following extraction methods were used for soil testing:
Extractant A: AL-solution, 0.1 *N* NH_4-lactate, pH = 3.75
soil:extractant ratio = 1:20 (EGNER et al., 1960)
Extractant B: 1 *N* NH_4-acetate, pH = 7.0,
soil:extractant ratio = 1:25 (WANASURIA et al., 1981).

The exchangeable K amounts (K_2O mg/kg soil) were measured by flame photometry.

Results

Results obtained with extractant A (AL-solution, pH 3.75)

It was observed that the AL-soluble potassium contents in the soils were higher in all the experimental soils after four weeks of incubation (see Figs. 1-3). The rate of increase differed depending on the soil types and K levels. The increases were highest in the unfertilized control (code No. 000), especially in the MO soil (79%), while at higher K levels (codes No. 441 and 442) these differences in AL-K_2O content were less pronounced.

The addition of a high constant dose (1000 kg K_2O/kg soil) at the start of the experiment resulted in significant increases in the AL-soluble potassium fraction of every soil type. The rates of K recovery were related to differences developing in the K supply of the soils during 20 years of fertilization. The recovery percentages varied between 21 and 68% and were lowest in the unfertilized control (000). These values increased with the K levels (441 and 442). The maximum recovery of added K was 68%, measured in MO soil with the highest rate of K fertilization (442). This is evidently related to the better potassium saturation of the clay minerals as a result of long-term fertilization.

Results obtained with extractant B (NH_4Ac-solution, pH = 7.0)

As a result of incubation, the changes in the potassium contents of the NH_4Ac extract were less than for the AL-extract. Both increases and decreases were measured, being independent of differences in the K levels. The highest increase was determined in KA soil, for the unfertilized control, while the largest decrease was recorded in HB soil.

The standard amount of K added at the start of the experiment resulted in considerably higher increases in the amount of NH_4Ac exchangeable potassium than in the AL-extract.

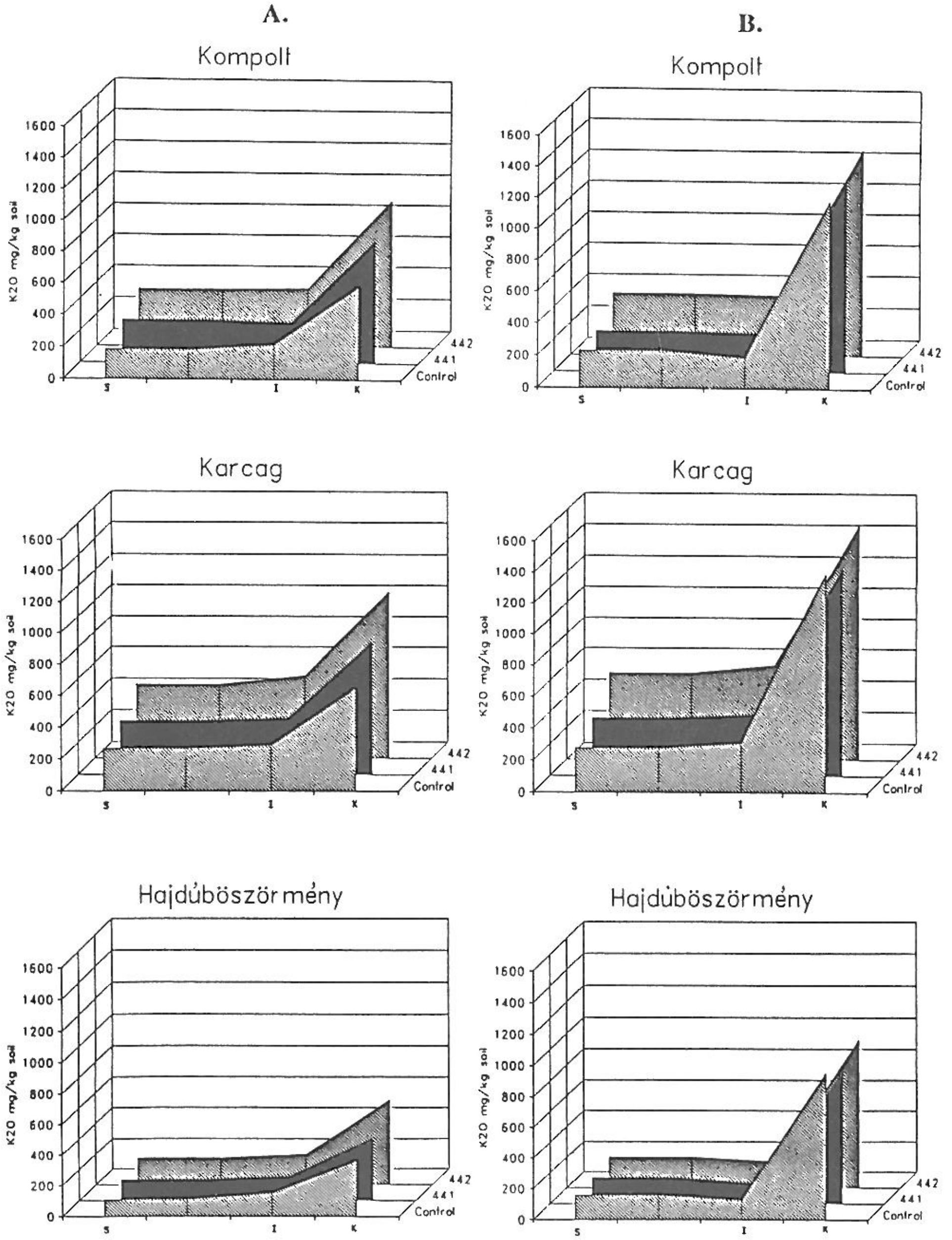

Fig. 1.
Changes in the exchangeable potassium content of the Kompolt (KO), Karcag (KA) and Hajdúböszörmény (HB) soils in an incubation experiment (28 days, 25 °C) using extractant A (AL solution) and extractant B (NH_4 acetate)

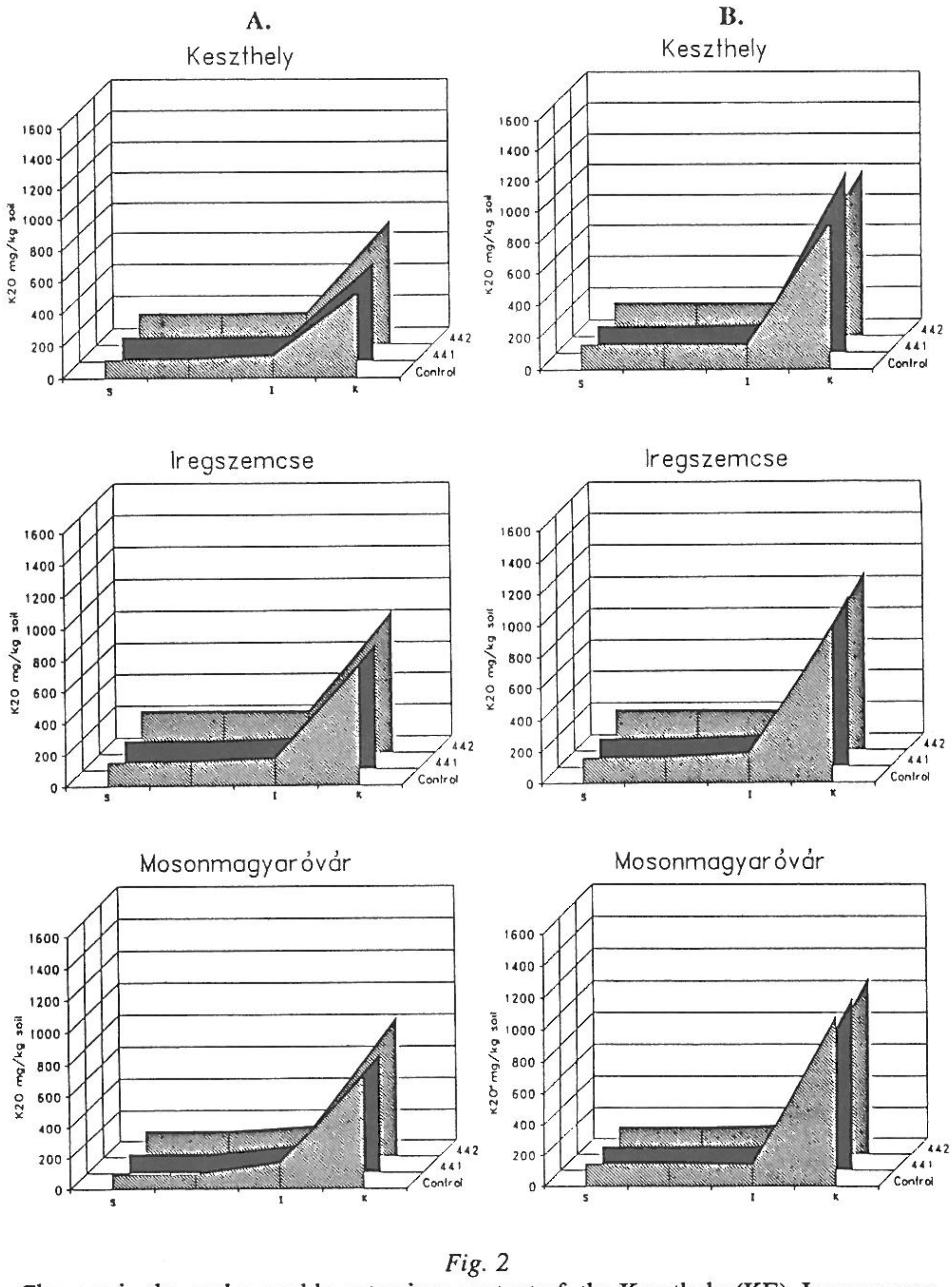

Fig. 2
Changes in the exchangeable potassium content of the Keszthely (KE), Iregszemcse (IR) and Mosonmagyaróvár (MO) soils in an incubation experiment (28 days, 25 °C) using extractant A (AL solution) and extractant B (NH_4 acetate)

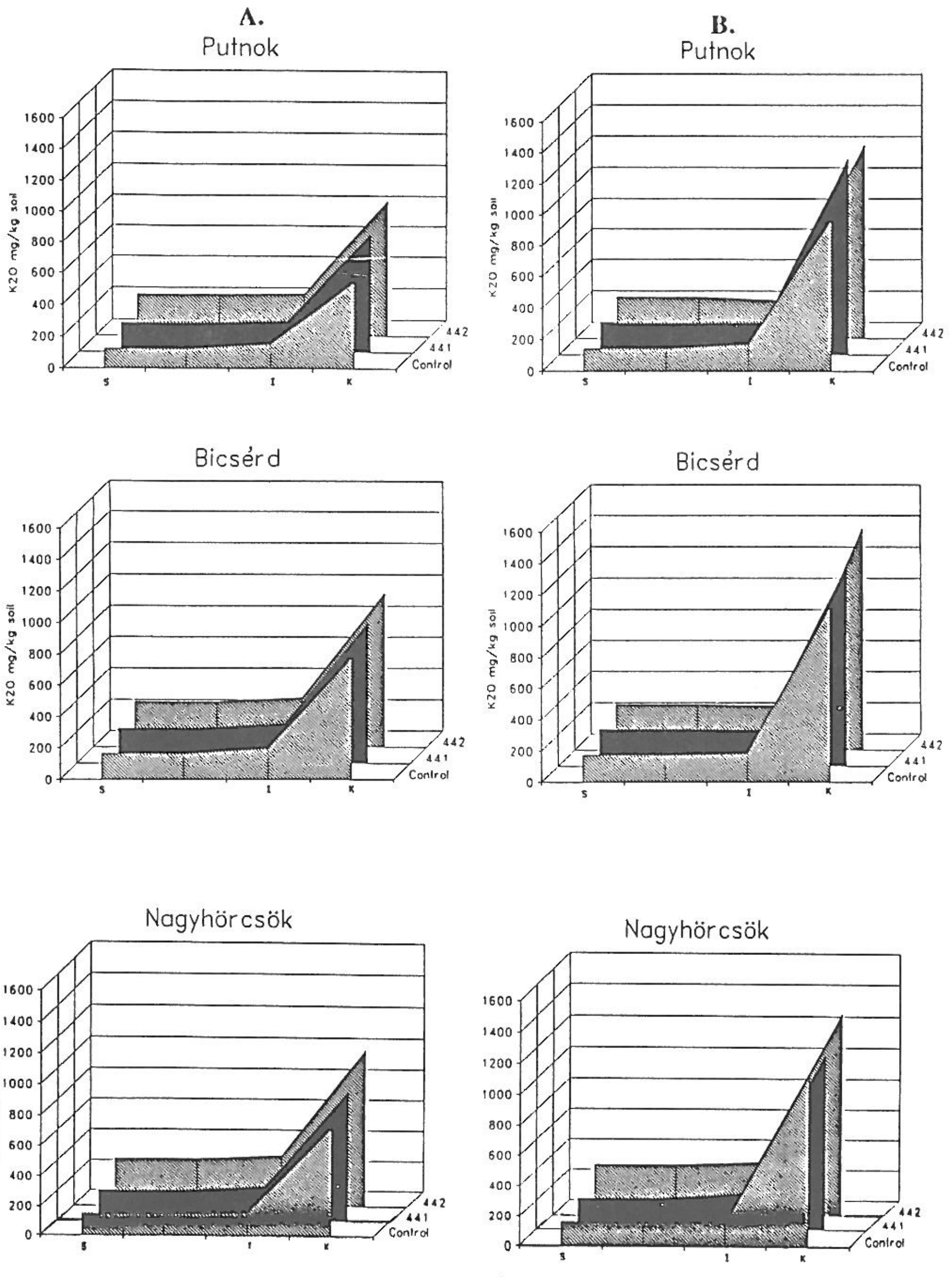

Fig. 3

Changes in the exchangeable potassium content of the Putnok (PU), Bicsérd (BD) and Nagyhörcsök (NH) soils in an incubation experiment (28 days, 25 °C) using extractant A (AL solution) and extractant B (NH_4 acetate)

The rates of recovery were significantly higher than those of AL-soluble K, even exceeding 100% in some cases (see Fig. 4).

The results obtained with the two extraction procedures were compared. A very close linear relationship was found between the values. Similarly close correlations were observed at the start of the experiment (r = 0.97 on average) and after 28 days of incubation (r = 0.98 on average), see Figs. 5, 6 and 7.

Discussion and Conclusions

As a result of incubation, the constant moisture favourable for plant uptake had a positive effect on the potassium fraction extractable by AL-solution. In the majority of experimental soils, the increases were highest at the lowest K level (000).

On the other hand, the incubation of the soil samples resulted in both decreases and increases in the NH_4Ac-exchangeable K content of the soils. The recovery of K was higher when using a neutral NH_4Ac extractant. At the same

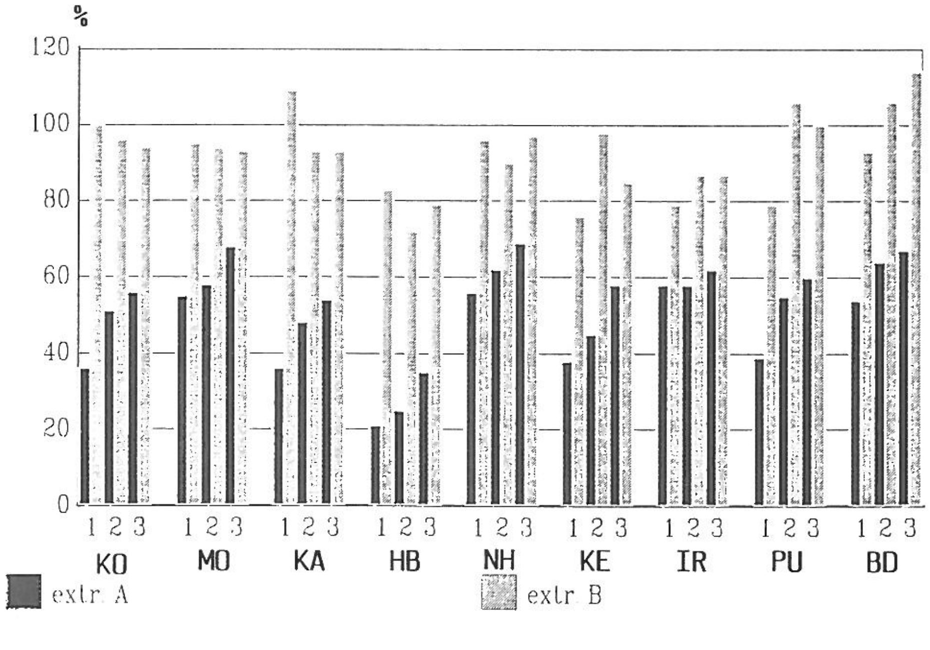

Fig. 4
Percentages of recovery after adding a constant dose of K. a) Extractant A; b) Extractant B. Treatments/Code No.: 1. 000; 2. 441; 3. 442.

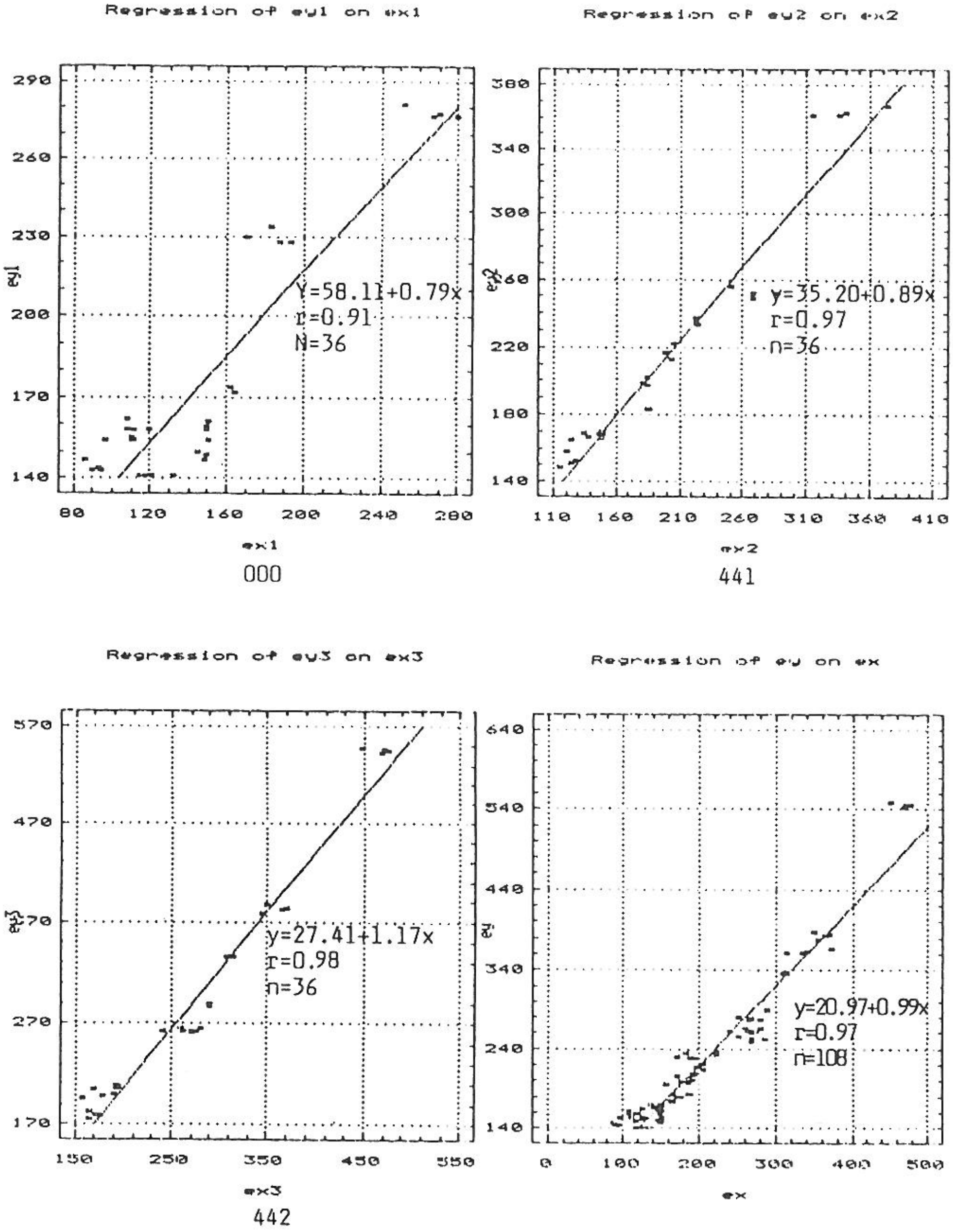

Fig. 5
Linear relationship between results (mg K_2O/kg soil) obtained with extractant A (x) and extractant B (y) at the starting of the experiment (S)

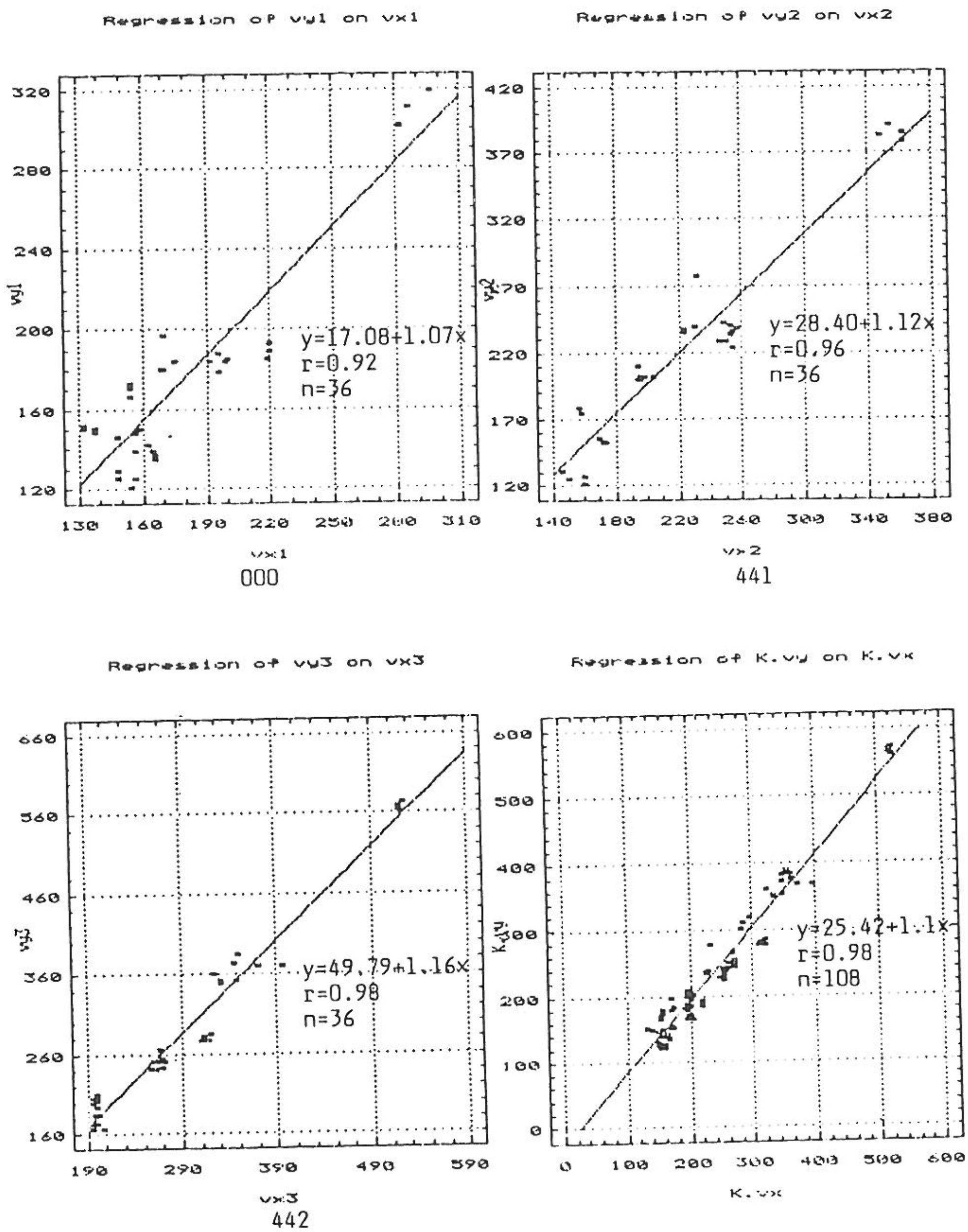

Fig. 6

Linear relationship between results (mg K_2O/kg soil) obtained with extractant A (x) and extractant B (y) after 28 days of incubation (I)

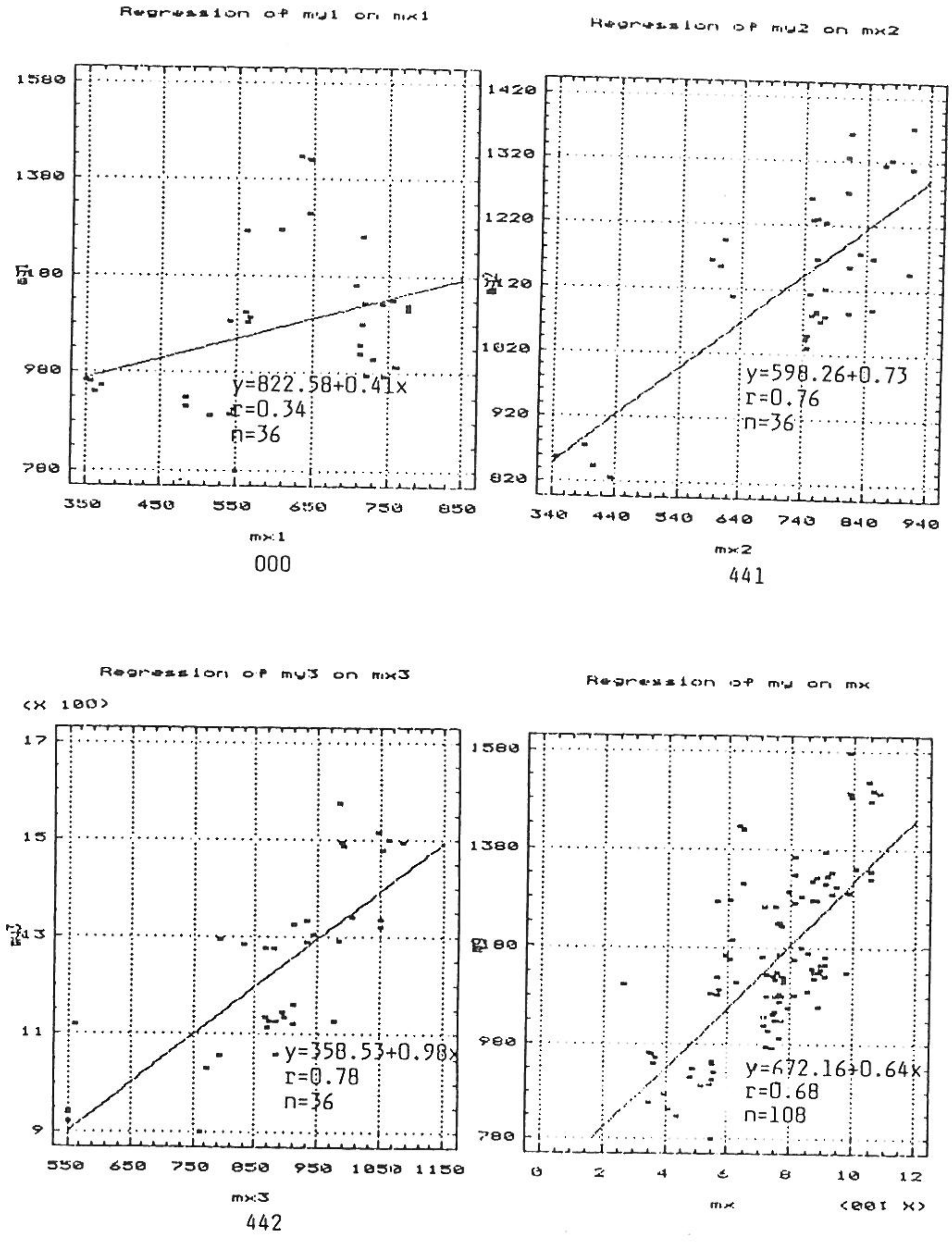

Fig. 7

Linear relationship between results (mg K_2O/kg soil) obtained with extractant A (x) and extractant B (y). As a result of added 1000 mg K_2O/kg soil after 28 days of incubation (K) time, comparing the two extractants, a very close linear relationship was found between them. Both extraction methods are rapid and simple and are thus suitable for routine soil tests.

Better K saturation of the clay minerals may result in a higher recovery of added potassium fertilizers. This was especially obvious when using AL-solution.

The soil K status is the most important factor in determining the K fertilizer requirement. Only long-term fertilization experiments with increasing rates of K can give reliable information for this work.

References

Blum, W. E. H., 1983., Kalium-dynamik im Boden. In: Dynamik und Verfügbarkeit des Kalis im Boden. Fachsymposium 1982. Heft. 4. Mai 1983. 1-20.

Diest, A. van, 1979. Factors affecting the availability of potassium in soils. IPI Research Topics. Bern. 37-59.

Egner, H., Riehm, H. & Domingo, W. R., 1960. Untersuchungen über die chemische Bodenanalyses als Grundlage für die Beurteilung des Nährstoffzustandes der Boden II. K. Lantbr. Högsk. Ann. **26.** 199.

Grimme, H. & Németh, K., 1979. The evaluation of soil K status by means of soil testing. IPI Research Topics. Bern. 5-48.

Grimme, H. et al., 1979. Some factors controlling potassium availability in soils. Proc. Int. Symp. on Soil Fertility Evaluation. **1.** 33-43.

Mengel, K., 1982. Factors of plant nutrient availability relevant to soil testing. Plant & Soil. **64.** 129-138.

Mengel, K. & Kirkby, E. A., 1987. Principles of Plant Nutrition. 4th ed. International Potash Institute. Bern.

Novozamski, I. & Houba, V. I., 1987. Critical evaluation on soil testing methods for K. Methodology in Soil-K Research. Proc. of the 20th Colloquium of IPI. Session No. 2. 177-197.

Quémener, J., 1979. The Measurement of Soil Potassium. IPI Research Topics No. 4. Bern. 5-48.

Sárdi, K. & Debreczeni, K., 1992. Studies on nutrient supplying capacity of different Hungarian soil types for reasonable fertilizer use. VIII Int. Colloquium for the Optimization of Plant Nutrition. Lisbon. Abstracts of Presentations. 213.

Tisdale, S., Nelson, W. & Beaton, J., 1990. Soil Fertility and Fertilizers. Maxwell-Macmillan Int. Editions.

Wanasuria, S., de Datta, S. K. & Mengel, K., 1981. Rice yield in relation to electroultrafiltration extractable soil potassium. Plant & Soil. **59.** 23-31.