Application of 0.01 *M* $CaCl_2$ Extraction Solution for the Assessment of Available N Content in Soil and Environmental Analyses

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Introduction

The excessive addition of N to soils results in the increased accumulation of nitrate-N and in its leaching by water percolating through the soil profile. Not only can environmental problems arise but also crop quality may decline and an excessive level of nitrate in crops may cause damage to human health.

A reliable soil test method on which the nitrogen fertilizer rate can be based is a prerequisite for adjusting nitrogen fertilizer rates to the available nitrogen in the soil (MENGEL, 1991).

Extraction methods to determine available soil N are more suitable for routine analysis than incubation techniques (KEENEY, 1982).

Over the past years a simple extracting solution of 0.01 *M* $CaCl_2$ was tested as an alternative to the conventional extracting procedure in use in various countries (HOUBA et al., 1986).

Arguments in favour of the 0.01 *M* $CaCl_2$ extraction procedure:

- the ionic strength in the diluted electrolyte remains almost constant during the extraction procedure,
- through extraction at a "constant" Ca concentration many cations in the extract can be seen as intensity parameters,
- in the single extract of a soil sample measurements can be made on: pH, soluble organic and inorganic C, N, P and S fractions, B, Na, K, Mg, Al, Mn, Cu, Cd, Pb, Ni and Zn,
- measurement in one extract allows the agrochemical interpretation of different ratios of elements.

Earlier, comparative studies were carried out in Hungary in cooperation with the research group of Wageningen Agricultural University. A correlation was found between the nutrient elements extractable in 0.01 *M* $CaCl_2$ and those extractable in other extracting agents (HOUBA et al., 1991).

In recent years the fraction of organic nitrogen extracted by $CaCl_2$ has received major attention (APPEL & MENGEL, 1990).

It is assumed that the soluble N_{org} fraction is particularly prone to mineralization. The long-term application of fertilizer and manure and the turnover of plant matter have an impact on the quantity of the N_{org} fraction (JÁSZBERÉNYI et al., 1994).

Table 1
Soil characteristics

No. of soil sample	pH (KCl)	$CaCO_3$ %	Humus %	Clay %	CEC meq/100 g
1.	6.2	-	1.8	15.4	14.4
2.	7.1	1.3	6.6	23.0	47.0
3.	6.7	-	1.6	21.9	18.3
4.	4.4	-	1.5	15.7	12.2
5.	7.2	28.6	2.7	25.4	29.0
6.	7.3	7.2	2.6	21.5	26.9
7.	4.0	-	1.1	9.4	8.2
8.	7.1	1.8	3.5	27.6	38.5
9.	7.1	5.3	4.2	28.3	47.4
10.	7.1	2.2	1.2	25.4	23.7
11.	7.3	5.9	2.5	29.1	26.3
12.	4.0	-	0.4	4.8	4.5
13.	4.2	-	0.7	7.4	6.6
14.	5.1	-	3.3	46.0	41.8
15.	3.6	-	10.0	24.3	135.5
16.	7.1	6.9	2.4	24.3	35.3
17.	7.8	12.3	0.3	2.5	3.7
18.	7.1	1.8	3.1	23.1	32.2
19.	5.8	-	6.4	36.3	56.1
20.	5.2	-	1.0	36.4	39.2
21.	6.0	-	4.8	34.1	33.1
22.	4.8	-	4.0	44.8	40.4
23.	5.5	-	3.9	53.3	44.8
24.	3.4	-	3.4	31.8	26.2
25.	6.6	0.7	2.0	23.2	19.3
26.	6.2	-	3.3	44.7	42.2
27.	5.8	-	2.9	46.9	41.2
28.	5.0	-	1.9	36.8	35.4
29.	6.3	-	2.3	30.3	31.7
30.	5.3	-	2.0	27.5	22.0
31.	3.9	-	2.0	31.3	27.3
32.	5.2	-	1.2	18.4	16.6
33.	5.6	-	3.4	44.5	41.4
34.	7.6	3.3	1.0	5.4	11.0
35.	7.1	2.8	3.3	16.3	28.0
36.	7.0	13.2	3.0	41.1	36.8

The objectives of the present investigation are:
- to analyze the different N forms of some Hungarian soils,
- to compare them with the conventional 2 *M* KCl extraction procedure,
- to estimate the quantity of residual N forms in soil samples from field fertilizer plot experiments.

Material and Methods

Soils

Laboratory investigations of 36 soil samples taken from different soil types and locations in Hungary (Table 1) were carried out, as well as analyses of soil samples from field fertilizer experiments on chernozem soil (No. 21 in Table 1).

Soil analyses

The air dried soil samples were extracted with 0.01 *M* $CaCl_2$ (1:10 ratio w/v) at 20-28 °C. After reaching equilibrium by shaking for 2 hours, the pH value in the suspension was measured. Part of the suspension was centrifuged for the determination of N forms. Nitrate, ammonium and the total soluble N content of the $CaCl_2$ extracts were analyzed by means of an autoanalyzer (SKALAR Segment Flow Analyzer).

The mineral (N_{min}) content was calculated from the sum of ammonium-N and nitrate-N:

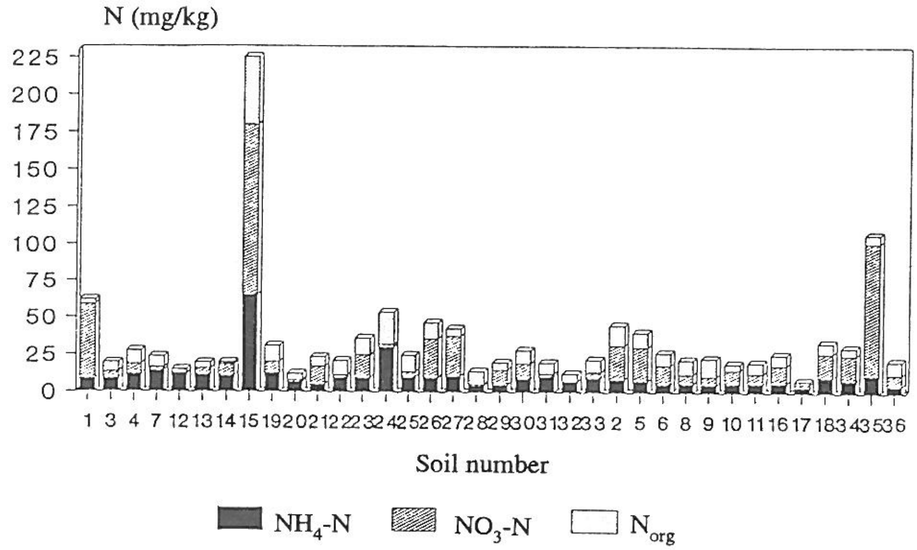
$$N_{min} = (NH_4\text{-}N) + (NO_3\text{+}N)$$

The soluble organic N (N_{org}) was also calculated from the difference between total soluble N and N_{min}:

$$N_{org} = \text{total soluble N} - N_{min}$$

Results and Discussion

The Hungarian soil samples are, with the exception of peat soil (No. 15), slightly different in their ammonium-N contents, bound non-specifically. There are remarkable differences in their nitrate-N and soluble organic N contents (Figure 1). There is a fairly strong correlation between the conventional pro-



$NH_4\text{-N} + NO_3\text{-N} + N_{org} = N_{total\ soluble}$

Figure 1

0.01 *M* $CaCl_2$-soluble N fractions in Hungarian soil samples

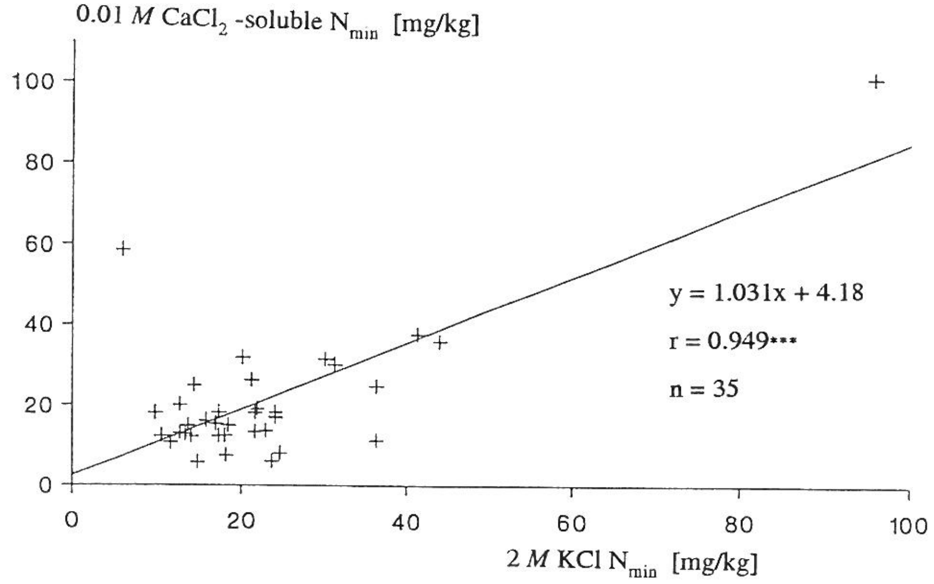


Figure 2

Relation between 0.01 *M* $CaCl_2$ -soluble N_{min} and 2 *M* KCl N_{min}

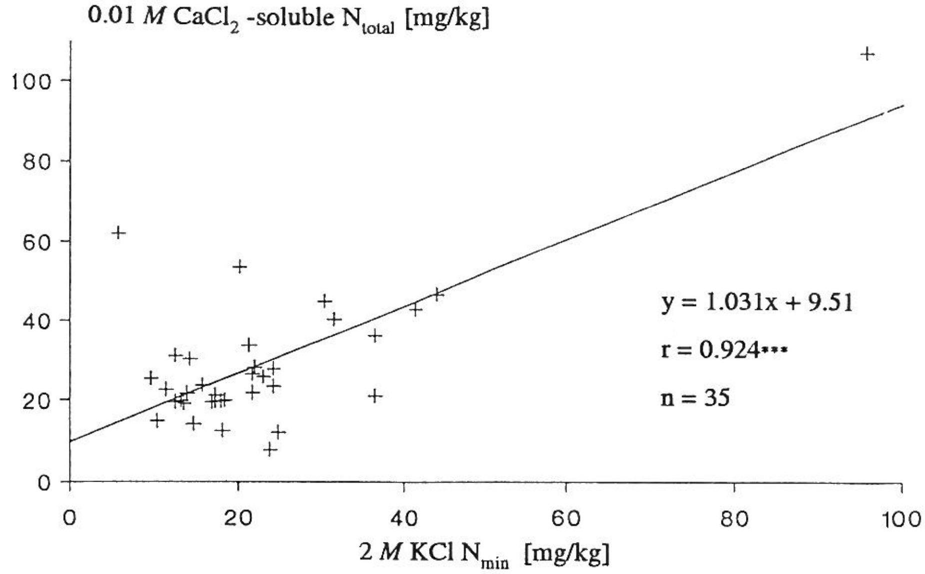


Figure 3
Relation between 0.01 *M* $CaCl_2$ -soluble N_{total} and 2 *M* KCl N_{min}

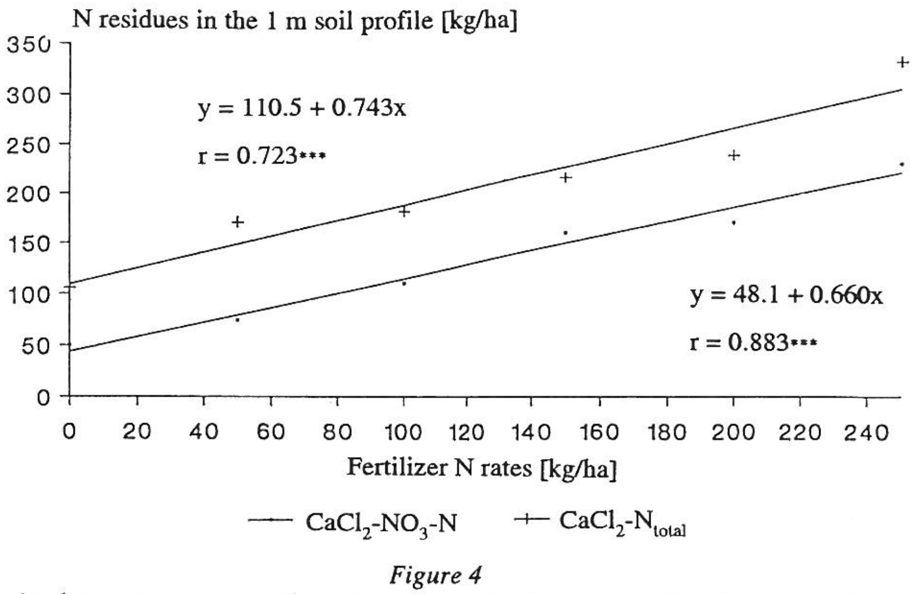


Figure 4
Relation between 0.01 *M* $CaCl_2$ -soluble residual N fraction and fertilizer rate in short-term experiment

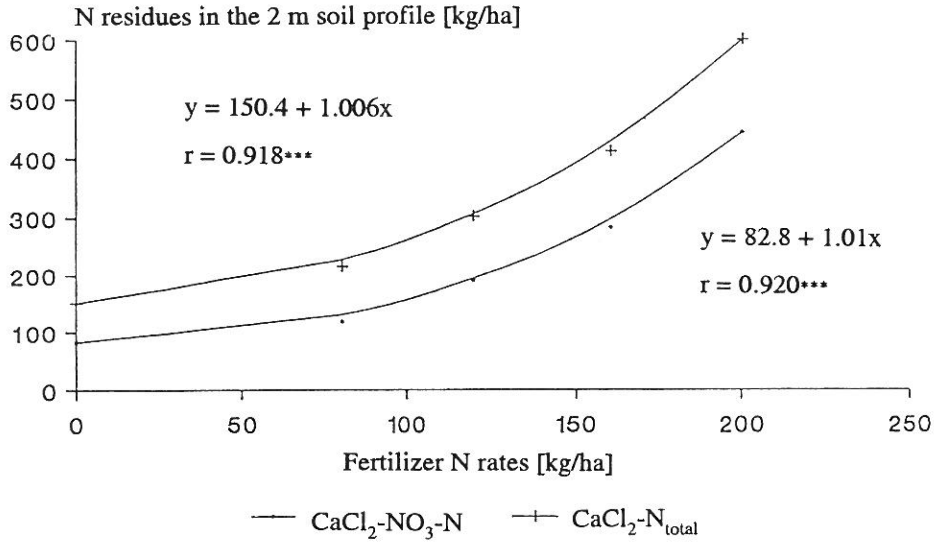


Figure 5
Relation between 0.01 *M* $CaCl_2$ -soluble residual N fraction and fertilizer rate in long-term experiment

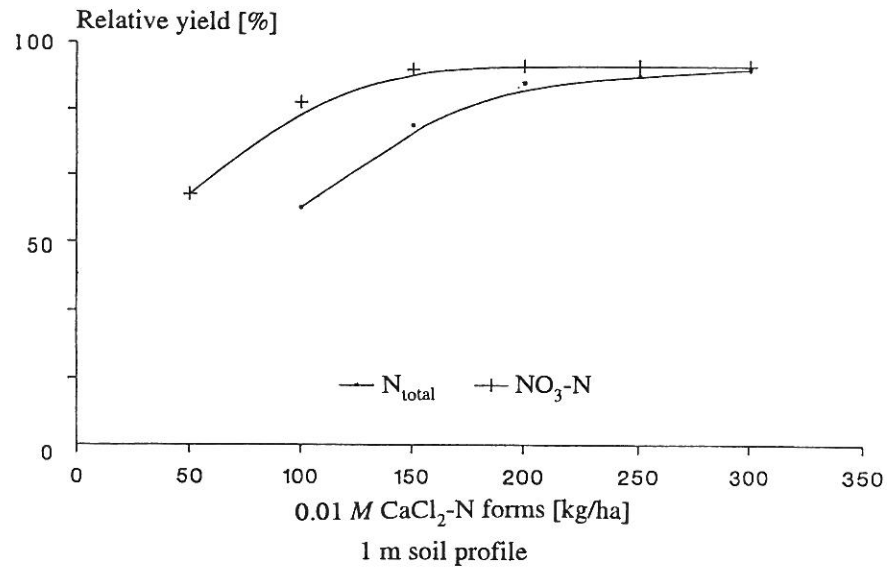


Figure 6
Relation between winter wheat yields and 0.01 *M* $CaCl_2$-soluble residual N forms

cedure and 0.01 *M* $CaCl_2$ soluble N_{min} and total soluble N (N_{tot}) (Figures 2 and 3).

The 0.01 *M* $CaCl_2$ soluble nitrate-N and N_{tot} residuals in the 100 cm soil profile rose linearly with the N-fertilizer rates in the short-term field experiment (Figure 4) but exponentially in the long-term field experiment on the same soil type (Figure 5). This is in a good agreement with the conclusions of SCHWEIGER (1985). A fairly high quantity of soluble N residues can be measured in the soil profile at the end of the growing season, especially in the case of long-term application of high rate N fertilizer. This means a rising risk of nitrate-N leaching in this soil type.

The relation between winter wheat yields and 0.01 *M* $CaCl_2$ soluble residual N forms (Figure 6) makes it possible to estimate the critical quantity of soluble N in the soil profile.

120-150 kg nitrate-N and 150-200 kg total soluble N are the residual N quantities in the 100 cm chernozem soil profile at the yield maximum.

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