A Laboratory Method for Evaluation of Available Nitrogen in Soil

A. ØIEN[1] and A. R. SELMER-OLSEN[2]

[1]Department of Soil Science and [2]Chemical Research Laboratory,
Agricultural University of Norway, 1432 Ås-NLH, Norway

I. Introduction

It should be of great interest to have a reliable and rapid method of evaluating the nitrogen status in soil. The best correlation between the N-index and the yield or the uptake of nitrogen in plants has been found when the index includes both the inorganic nitrogen in the soil and the nitrogen being released from the organic compounds by incubation or by chemical methods. Stanford & Legg (1967) obtained very good correlations between N-indexes and the uptake of nitrogen or A-values by use of multiple regression analyses.

Incubation of the soil is found to be one of the most reliable methods of evaluating the nitrogen reserve in soil organic matter. It is, however, difficult to get satisfactory reproducibility because the analytical results are dependent on both pretreatment and storage of the soil. Another problem is that moisture, temperature, and leaching, are important factors influencing the availability of nitrogen during the growing season. Van Dijk (1972) suggests that Kjeldahl-N might be as good as other N-indexes. Keeney & Bremner (1966) and Bronner & Bachler (1979) proposed a boiling of the soil with distilled water and Smith & Stanford (1971) treated the soil in an autoclave before nitrogen determination.

In our investigations we have tried to find a simple chemical method unaffected by pretreatment of soil where the results have a good correlation with the total NO_3-N content after aerobic incubation of fresh soil. Pot experiments have already shown that the N-index from aerobic incubation agrees well with the N-uptake in common ryegrass (Bærug et al., 1973).

II. Experiments

When heating soil with 2 M KCl a release of ammonium, dependent on the organic matter in the soil, takes place. This could possibly be utilized in a method to evaluate available nitrogen in soil. Use of 2 M KCl makes the analytical procedure more convenient because automatic methods can be used for determination of nitrate and ammonium in 2 M KCl soil extracts.

Heating of soil in 2 M KCl at different temperatures

Soil samples were heated with 2 M KCl in 50 ml flasks with polypropylene screw caps. Heating to temperatures between 95 and 110°C in autoclave was tried, but even if teflon liner was used, a small change in liquid volume occurred. By heating to 80°C in a water bath or in a temperature-controlled oven, no change was observed. Even if less ammonium was released compared to higher temperatures, 80°C was preferred.

Variation of heating time at 80°C

Table 1 shows data for the soil samples used in this investigation. The samples were heated 0, 6, 12, 20, and 48 hours with 2 M KCl at 80°C and the content of ammonium-N was determined afterwards. Table 2 shows the NH_4-N content in all samples both when fresh and air-dried samples were used.

Table 1. *Soil characteristics*

Soil	Texture	O.M. %	pH
a	Clay	5.8	6.2
b	Clay	10.1	5.4
c	Sand	5.7	5.2
d	Sand	3.8	5.9
e	Sand	3.4	5.5
f	Peat soil rich in clay	25.5	5.2
g	Peat soil rich in clay	39.3	4.7
h	Peat soil	63.3	4.4
i	Peat soil rich in clay	22.1	5.4
j	Peat soil rich in clay	34.7	6.0
k	Peat soil	65.5	5.3
l	Peat soil rich in clay	32.3	5.7
m	Peat soil	60.9	5.3
n	Clay	5.4	5.8

Table 2. *The influence of heating time on the release of ammonium from soil at 80°C in 2 M KCl, mg N/100 g dry soil*

Heating time in hours ...	Air-dried soil					Fresh soil				
	0	6	12	20	48	0	6	12	20	48
Soil										
a	0.05	0.90	1.40	2.16	3.81	0.00	0.93	1.53	1.91	4.03
b	0.06	0.70	2.01	2.91	5.62	0.00	1.26	2.20	2.68	5.24
c	0.00	0.40	1.00	1.30	2.51	0.00	0.61	1.23	1.28	2.56
d	0.05	0.50	1.00	1.40	2.60	0.37	0.71	1.74	1.53	3.17
e	0.10	0.40	0.90	1.10	2.00	0.12	0.30	0.91	0.97	1.73
f	0.54	2.22	4.53	6.90	12.10	0.16	2.22	4.33	6.18	10.60
g	0.98	4.13	8.47	12.90	20.20	0.22	4.09	8.40	11.30	18.80
h	2.90	8.37	12.30	19.40	28.00	0.92	7.48	11.40	15.40	25.50
i	0.90	2.73	4.86	7.54	11.60	0.17	2.14	4.35	6.85	11.30
j	0.69	3.45	7.10	10.10	20.30	0.20	3.50	7.55	13.10	19.50
k	1.72	7.61	12.20	19.80	33.50	0.52	8.84	13.20	19.90	32.70
l	0.54	2.52	4.94	7.36	12.10	0.29	2.59	4.65	6.54	14.10
m	4.31	6.52	10.20	14.30	16.30	0.68	4.54	7.64	11.20	20.80
n	0.36	0.70	1.40	2.11	3.40	0.14	0.73	1.25	1.92	3.70

Drying of the soil did not change significantly the amount of ammonium released. The release continued for 48 hours at least, but it decreased slightly between 20 and 48 hours, especially when the soil was rich in organic matter.

The amount of nitrate was independent of the time of heating for 48 hours at least, both for fresh and air-dried soil as seen from Table 3.

Variation of the ratio of soil to the extracting solution (weight/volume)

Three different soils were used to see if a variation in the soil/2 M KCl ratio changed the amount of nitrogen released when the samples were heated to 80°C for 20 hours. The results are given in Table 4.

It is seen that a change in the ratio had no significant influence. Samples I and II, however, showed differences in the amount of released ammonium between the parallels when the soil/liquid ratio reached 8 g/40 ml. The nitrate released seemed to be independent of the ratio for the range used in this experiment.

Table 3. *The influence of heating time on the nitrate content in soil at 80°C in 2 M KCl, mg N/100 g dry soil*

Heating time in hours ...	Air-dried soil					Fresh soil				
	0	6	12	20	48	0	6	12	20	48
Soil										
a	0.46	0.60	0.55	0.53	0.55	0.41	0.41	0.43	0.44	0.36
b	1.19	1.26	1.20	1.23	1.26	0.77	0.84	0.75	0.82	0.73
c	0.28	0.30	0.32	0.32	0.45	0.27	0.31	0.31	0.31	0.36
d	1.37	1.55	1.50	1.53	1.50	0.86	1.28	0.92	1.02	0.87
e	0.84	0.85	0.85	0.90	0.90	0.58	0.61	0.61	0.66	0.56
f	2.94	3.02	3.02	3.07	3.07	2.01	1.85	2.06	2.03	1.85
g	7.89	7.76	7.96	8.01	7.86	6.08	6.35	6.08	6.22	5.97
h	10.00	9.80	9.70	9.40	10.00	9.34	9.97	9.02	9.28	9.26
i	3.16	3.09	3.19	3.16	3.24	2.18	2.34	2.37	2.32	2.23
j	3.74	3.75	3.70	3.85	3.75	2.55	2.85	2.68	2.74	2.63
k	5.99	6.19	5.98	5.35	6.08	4.92	5.34	4.88	4.99	4.65
l	19.00	19.70	18.70	18.40	19.20	17.00	15.80	17.30	16.80	16.20
m	18.20	18.30	19.40	18.30		17.10	16.10	16.70	16.70	15.20
n	1.60	1.60	1.71	1.76	1.55	1.22	1.19	1.19	1.25	1.09

Table 4. *The influence of varying the ratio of air-dried soil to 2 M KCl by heating 20 hours at 80°C*

Soil	Texture	Loss on ignition (%)	g soil/ml 2 M KCl	Mg NO_3–N/100 g dry soil			Mg NH_4–N/100 g dry soil		
				1	2	Mean	1	2	Mean
I	Clay	13.8	8:40	0.48	0.48	0.48	3.15	3.46	3.31
			4:40	0.47	0.47	0.47	3.81	3.70	3.76
			4:80	0.47	0.47	0.47	3.70	3.70	3.70
			2:80	0.53	0.53	0.53	3.70	3.70	3.70
II	Sand	19.3	8:40	2.86	2.86	2.86	7.03	7.55	7.29
			4:40	3.20	2.99	3.10	7.38	7.38	7.38
			4:80	3.07	3.07	3.07	7.38	7.26	7.32
			2:80	3.03	3.03	3.03	7.46	7.46	7.46
III	Sand	4.7	8:40	0.75	0.73	0.74	3.14	3.19	3.17
			4:40	0.79	0.76	0.78	3.34	3.34	3.34
			4:80	0.77	0.77	0.77	3.04	3.04	3.04
			2:80	0.81	0.81	0.81	3.24	3.24	3.24

Influence of shaking during the heating period

Fourteen soil samples in 2 M KCl (4 g/40 ml) were placed in a shaking incubator at 80°C to see if shaking during the heating period had any effect on the amount of released ammonium. The ammonium content was determined after 6, 12, 20, and 48 hours. Table 5 shows that shaking of the samples during the heating period had little effect upon the release of ammonium.

Procedure

Based on the results of our investigations the following analytical method is proposed: 4 g air-dried and sieved soil (or equivalent amounts of fresh soil) are transferred to a 50 ml glass bottle, 40 ml 2 M KCl is added, and the bottle is closed with a teflon liner and a polypropylene screw cap. The bottle is shaken by hand and placed in a water bath at 80°C for 20 hours. After cooling down to room temperature the sample is shaken for a short time and thereafter the suspension is filtered through Whatmans glass microfibre filter GF/C. The ammonium and nitrate are determined colorimetrically by autoanalyzer according to Selmer-Olsen (1971) and Henriksen & Selmer-Olsen (1970).

Precicion

Duplicate analysis of 43 samples using this method showed that the reproduceability was good. The variation coefficient calculated from the deviation between the parallel determinations and the average of all samples, was 3.6%.

A preliminary comparison of the results from this method with some other N-indexes

It is of interest to compare the amount of nitrogen released by heating for 20 hours in 2 M KCl with nitrogen released by other methods. Table 6 shows analytical results of 14 soil samples after different treatments and Table 7 shows the correlation coefficients according to linear regression analyses.

Correlation between the analytical data from aerobic incubation of fresh soil and the proposed method

As seen from the preliminary investigation there was good correlation between the results of the proposed method and those obtained by aerobic incubation of fresh soil. To verify these results 43 soil samples having great variation in organic matter, soil type and pH were analysed ac-

Table 5. *The effect of shaking on the released NH_4-N from soil for various heating times at 80°C in 2 M KCl, (a) without and (b) with shaking, mg N/100 g dry soil*

Soil	Heating time in hours							
	6		12		20		48	
	a	*b*	*a*	*b*	*a*	*b*	*a*	*b*
a	0.9	0.8	1.4	1.6	2.2	2.1	3.8	4.1
b	0.7	1.5	2.0	2.3	2.9	3.1	5.6	5.9
c	0.4	0.5	1.0	1.0	1.3	1.5	2.5	2.6
d	0.5	0.6	1.0	1.1	1.4	1.4	2.6	2.7
e	0.4	0.5	0.9	0.9	1.1	1.2	2.0	2.2
f	2.2	3.0	4.5	4.5	6.9	6.5	12.1	14.0
g	4.1	5.2	8.5	10.9	12.9	13.1	20.2	18.5
h	8.4	10.7	12.3	16.1	19.4	19.2	28.0	38.3
i	2.7	5.0	4.9	6.4	7.5	8.5	11.6	14.7
j	3.5	6.0	7.1	9.2	10.1	10.9	20.3	19.6
k	7.6	9.5	12.2	14.9	19.8	17.8	33.5	35.6
l	2.5	3.6	5.0	5.6	7.4	7.1	12.1	11.9
m	6.5	9.7	10.2	13.3	14.3	16.4	16.3	26.7
n	0.7	1.0	1.4	1.4	2.1	2.0	3.4	3.7

Table 6. *Various N-indexes*

A and B, g/100 g dry soil, the rest mg/100 g dry soil. A = organic matter; B = total N; C = NO_3-N, air-dried soil; D = total min. N, after aerobic incubation of air-dried soil; E = Δ min. N, after aerobic incubation of air-dried soil; F = total min. N, after heating air-dried soil 20 hours in 2 M KCl at 80°C; G = Δ min. N, after heating air-dried soil 20 hours in 2 M KCl at 80°C; H = NO_3-N, in fresh soil; I = Total min. N after aerobic incubation of fresh soil; J = Δ min. N after aerobic incubation of fresh soil; K = total min. N, after heating fresh soil 20 hours in 2 M KCl at 80°C; L = Δ min. N, after heating fresh soil 20 hours in 2 M KCl at 80°C; Δ min. N = the increase of mineral N during incubation

Soil	A	B	C	D	E	F	G	H	I	J	K	L
a	5.8	0.33	0.5	5.7	5.2	2.7	2.1	0.4	3.0	2.6	2.4	1.9
b	10.1	0.47	1.2	8.4	7.1	4.1	2.8	0.8	3.5	2.7	3.5	2.7
c	5.7	0.20	0.3	2.9	2.6	1.6	1.3	0.3	2.0	1.7	1.6	1.3
d	3.8	0.17	1.4	5.4	4.0	2.9	1.3	0.9	2.8	1.5	2.6	1.1
e	3.4	0.15	0.8	3.0	2.1	2.0	1.0	0.6	1.7	1.0	1.6	0.9
f	25.5	1.00	2.9	9.6	6.1	10.0	6.4	2.0	6.0	3.9	8.2	6.0
g	39.3	1.18	7.9	26.4	17.5	20.9	11.9	6.1	17.0	11.2	17.6	11.1
h	63.3	1.83	10.0	32.9	20.0	29.0	16.5	9.3	19.6	9.9	24.7	14.5
i	22.1	0.94	3.2	14.4	10.3	10.7	6.6	2.2	7.3	5.1	9.2	6.7
j	34.7	1.22	3.7	22.6	18.2	13.9	9.4	2.6	11.0	8.7	15.9	12.9
k	65.5	2.55	6.0	33.9	26.2	25.1	18.1	4.9	14.7	9.3	24.8	19.3
l	32.3	1.02	19.0	29.2	9.7	25.8	6.9	17.0	20.4	3.1	23.3	6.2
m	60.9	1.72	18.2	48.4	25.9	32.6	10.0	17.1	21.1	3.8	27.9	10.6
n	5.4	0.31	1.6	5.8	3.8	3.9	1.7	1.2	2.9	1.6	3.2	1.8

cording to these two methods. The results are shown in Table 8. As seen from Fig. 1, a very good correlation ($r = 0.98$) was once again obtained.

The difference in inorganic N before and after incubation of fresh soil, Δ mineral N_{aerob}, was of the same order of magnitude as the content of ammonium-N after heating in 2 M KCl. The correlation between these N-indexes is again very good ($r = 0.92$) as seen from Fig. 2.

Effect of storage of fresh soil samples on the analytical results

In Norway most of the soil samples are collected during a relatively short period in the autumn. Because it is impossible to begin work on all soil samples as soon as they have been collected in the field, it is of great importance to know if the analytical results are influenced by storage prior to analysis.

Eight samples of fresh soil were stored as usual in pasteboard boxes or in closed polyethylene bags for one month at 20–22°C. As the pasteboard boxes were not airtight, the soil samples dried during the period. This, however, was not the case for the polyethylene bags. After a month of storage, some of the samples were dried before analyzing, and some of them were analysed directly according to the proposed method. Table 9 shows the results.

The content of NO_3-N increased during

Table 7. *The correlation between the N-indexes given in Table 6 (linear regression)*

	B	C	D	E	F	G	H	I	J	K	L
A	0.972	0.69	0.94	0.95	0.95	0.96	0.68	0.89	0.76	0.95	0.94
B		0.67	0.87	0.94	0.87	0.97	0.56	0.80	0.77	0.90	0.97
C			0.86	0.61	0.88	0.52	0.998	0.91	0.28	0.85	0.47
D				0.93	0.977	0.82	0.85	0.95	0.62	0.978	0.81
E					0.88	0.91	0.60	0.83	0.77	0.91	0.93
F						0.85	0.87	0.983	0.64	0.991	0.81
G							0.49	0.80	0.89	0.88	0.978
H								0.89	0.24	0.84	0.44
I									0.65	0.973	0.76
J										0.67	0.89
K											0.86

Table 8. *Total min. N after aerobic incubation of fresh soil and total min. N after heating air-dried soil 20 hours at 80°C in 2 M KCl, mg N/100 g dry soil*

Soil no.	Texture	Loss on ignition (%)	pH	Aerobic incubation	Heating in 2 M KCl		
					1	2	Mean
1	Clay	9.8	6.0	6.23	3.95	4.15	4.05
2	Clay	8.8	5.8	3.98	3.18	3.23	3.21
3	Clay	13.8	6.0	3.10	3.75	3.90	3.83
4	Clay	19.5	6.0	6.68	5.78	5.99	5.89
5	Peat soil	37.2	5.7	10.10	13.10	13.10	13.10
6	Peat soil	27.6	5.5	15.70	16.80	17.00	16.90
7	Peat soil	34.9	5.6	10.60	12.90	13.30	13.00
8	Peat soil	34.2	5.8	9.76	12.40	12.60	12.50
9	Clay	17.4	5.0	16.90	16.80	17.50	17.10
10	Clay	16.3	6.0	2.71	3.30	3.35	3.33
11	Sand	6.7	5.5	2.49	2.65	2.60	2.63
12	Sand	6.9	5.2	2.71	2.71	2.76	2.74
13	Sand	7.8	5.2	2.31	3.01	2.91	2.96
14	Sand	7.8	5.2	2.36	2.71	3.01	2.86
15	Sand	19.3	4.7	8.11	9.67	10.50	10.10
16	Sand	5.5	6.0	2.31	2.18	2.13	2.16
17	Sand	5.1	5.7	2.52	1.78	1.99	1.89
18	Sand	4.5	5.0	1.94	1.52	1.42	1.47
19	Sand	6.1	5.3	2.35	1.73	1.48	1.61
20	Sand	6.3	5.3	2.49	1.93	1.78	1.86
21	Clay	7.1	5.8	3.55	2.61	2.30	2.46
22	Sand	4.7	4.6	4.24	3.70	3.65	3.68
23	Sand	3.8	5.4	2.20	1.97	1.72	1.85
24	Sand	6.3	5.5	2.29	1.98	1.93	1.96
25	Clay	5.9	6.6	2.26	1.79	1.64	1.72
26	Clay	2.6	6.5	0.31	0.25	0.30	0.28
27	Clay	6.9	6.3	2.50	2.30	2.30	2.30
28	Sand	4.2	6.0	2.33	1.83	1.93	1.88
29	Sand	3.2	5.6	2.04	2.01	2.17	2.09
30	Clay	7.6	6.0	2.57	2.40	2.25	2.33
31	Clay	12.1	6.3	8.38	4.05	4.41	4.23
32	Peat soil	72.1	4.8	58.30	51.00	53.20	52.10
33	Peat soil	50.1	5.5	27.60	31.80	32.90	32.40
34	Clay	28.8	5.8	18.10	17.50	17.40	17.50
35	Clay	20.4	5.7	13.80	13.70	13.80	13.80
36	Clay	8.8	6.2	2.40	2.12	2.51	2.67
37	Clay	6.7	7.5	4.35	3.99	3.89	3.94
38	Clay	6.7	7.7	4.40	3.28	3.38	3.33
39	Lime sand of shells	1.6	8.2	0.61	0.33		0.33
40	Clay	6.1	7.7	2.73	3.11	2.96	3.04
41	Clay	8.1	6.9	3.37	2.92	3.03	2.98
42	Clay	8.9	6.8	5.38	4.28	4.33	4.31
43	Clay	6.9	7.1	3.61	2.10	2.10	2.10

storage, especially when stored in polyethylene bags. The ammonium content after heating the stored soil in 2 M KCl was nearly the same for fresh soil and the soil which had been air-dried after storage. As long as the amount of extractable ammonium was usually very low in the original soil, the amount of ammonium found after heating in 2 M KCl, was approximately equal to the amount of ammonium released.

III. Discussion and Conclusions

To evaluate the nitrogen reserve in soil a considerable number of laboratory methods have been proposed. Most of them are time-consuming and laborious. We have therefore tried to introduce a simple and rapid method where automatic analytical methods for the determination of nitrogen in the extracts can be used.

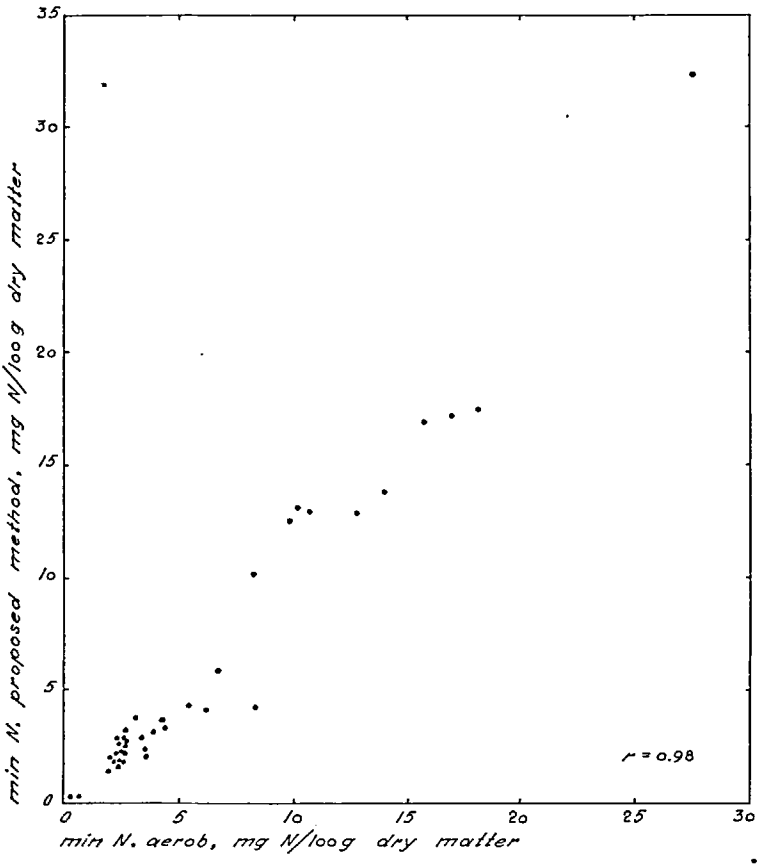

Fig. 1. Relationship between total min. N after heating air-dried soil 20 hours at 80°C in 2 M KCl, and total min. N after aerobic incubation of fresh soil.

The experiences with the proposed method can be summarized as follows:

1. The analytical results expressed on a dry matter basis are nearly the same for fresh and air-dried soil.
2. The NO_3-N content in soil was not affected by heating in 2 M KCl at 80°C.
3. The analytical results are influenced very little by the soil-KCl solution ratios investigated.

Table 9*a*. *One month storage of fresh soil*

Effect on exchangeable NO_3-N and NH_4-N, mg N/100 g dry soil

	NH_4-N						NO_3-N					
				Air-dried soil after storage						Air-dried soil after storage		
Soil	a	b	c	a	b	c	a	b	c	a	b	c
1	0.00	0.20	0.00	0.36	0.20	0.30	1.13	1.58	6.74	1.39	3.42	6.92
2	0.00	0.20	0.00	0.31	0.10	0.20	0.26	1.12	4.30	0.98	1.89	4.30
3	0.00	0.10	0.00	0.31	0.10	0.20	0.18	0.90	3.51	0.46	1.44	3.46
4	0.00	0.10	0.00	0.31	0.21	0.20	0.66	1.51	6.60	1.10	2.43	6.32
5	0.00	0.21	0.00	0.43	0.66	0.31	0.81	4.01	12.60	1.39	4.55	13.00
6	0.00	0.21	0.00	0.42	0.21	0.36	10.80	9.09	18.70	10.20	12.60	18.60
12	0.00	0.10	0.17	0.26	0.10	0.20	0.40	0.71	4.23	0.59	1.17	3.52
14	0.00	0.10	0.00	0.26	0.00	0.20	0.58	0.77	3.30	0.64	1.07	3.52

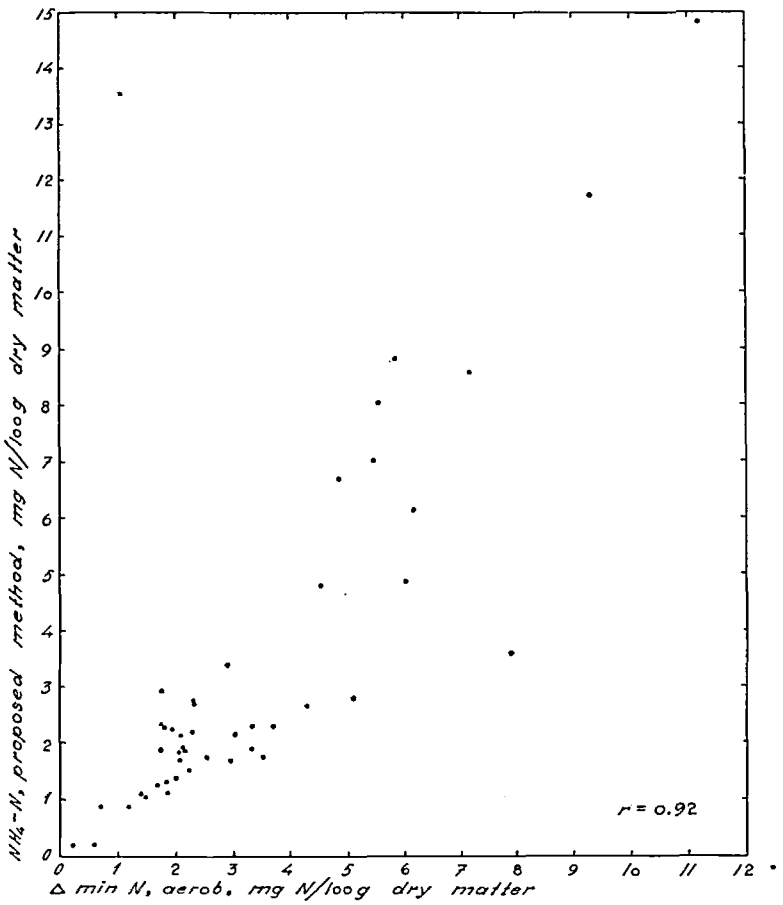

Fig. 2. Relationships between total NH_4-N after heating air-dried soil 20 hours at 80°C in 2 M KCl, and Δ min. $N_{aerobic}$ for fresh soil.

4. Shaking of the samples during heating in 2 M KCl had no serious influence on the results.

5. The precision was good.

6. The analytical results for this method and for aerobic incubation are of the same order of magnitude and the correlation between them is very good. Released ammonium, Δ NH_4-N and Δ mineral N with aerobic incubation of fresh soil are also of the same order of magnitude. A high correlation between these N-indexes was found.

7. The nitrate content increased during storeage of fresh soil for one month, while the ammonium released after heating 20 hours in 2 M KCl was nearly constant.

The analytical results of the proposed method are the sum of initial inorganic N and Δ NH_4-N,

Table 9*b*. *One month storage of fresh soil*

Effect on the release of NH_4-N by heating 20 hours at 80°C in 2 M KCl, mg N/100 g dry soil. a = unstored fresh soil, b = fresh soil stored in pasteboard boxes, c = fresh soil stored in polyethylene bags

				Air-dried after storage		
Soil	a*	b	c	a	b	c
1		2.55	2.22	2.77	2.66	2.43
2		2.30	2.01	2.31	2.35	1.97
3		3.46	3.46	3.40	3.59	3.15
4		5.21	5.12	4.90	5.27	4.48
5		10.70	10.20	11.80	11.60	10.50
6		6.94	6.61	6.72	6.77	6.27
12		2.03	2.30	2.20	2.24	2.17
14		2.45	2.45	2.30	2.14	2.43

* Not determined because Table 2 shows no significant difference between fresh and air-dried soil.

where Δ NH_4-N is nearly the same as the total NH_4-N after heating the soil samples. NH_4-N was nearly the same for fresh soil samples as for soil stored rather a long time. It is therefore reasonable to believe that this parameter can be used as an N-index even when the samples were collected in the autumn.

The nitrate content in the field may vary considerably during the winter and should therefore be analysed in samples collected just before fertilizing and seeding in the spring.

This method is simple and it might be useful in attempts to evaluate the nitrogen status in soil. Pot and field investigations, however, are necessary to ascertain how useful it might be.

IV. Summary

A simple and rapid laboratory method of evaluating the nitrogen status in soil has been proposed. Four grams of air-dried soil or the equivalent amount of fresh soil are heated for 20 hours at 80°C in 40 ml 2 M KCl. The soil extract contains the original inorganic nitrogen in the soil plus the ammonium (Δ NH_4-N) released from the organic matter. This amount of N is nearly the same as *inorganic N* (NO_3-N) in fresh soil after aerobic incubation for 14 days at 30°C. The correlation between these two N-indexes for 43 soil samples, with great variations in organic matter, was very good ($r = 0.98$). This indicates that the analytical results from the proposed method might provide good information about available nitrogen in the soil.

The content of NH_4-N found by the proposed method and Δ *mineral N* found by aerobic incubation were also of the same order of magnitude and the correlation between them was good ($r = 0.92$).

The analytical results referred to dry matter were the same for fresh and air-dried samples. Variation in soil:KCl ratio between 1:5 and 1:40, and shaking during the heating period had only small influence on the results. The NO_3-N content of the soil was not affected by heating in 2 M KCl.

The content of NO_3-N increased during storage of fresh soil while the released NH_4-N after the proposed method was not affected by storage at all.

Nitrate and ammonium were determined colorimetrically in 2 M KCl extracts using automatic methods. The precision of the method was good. The variation coefficient for 43 soil samples was 3.6%.

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Ms received December 4, 1979

Printed April 11, 1980