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Modification of the acid permanganate method for obtaining an index of soil nitrogen availability

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Summary The acid permanganate method proposed as a chemical index of soil nitrogen (N) availability simply measures the mineralizable N. A modification of the method has been proposed that allows the estimation of soil mineral N simultaneously. The N values obtained by the modified method correlated highly significantly with the mineral N of incubation test ($r = 0.80, P < 0.01$) and plant uptake ($r = 0.69, P < 0.01$).

Introduction

Numerous biological and chemical methods for measuring soil nitrogen (N) availability have been reported[1,3,6]. Biological methods involving soil incubations though time consuming, provide a good index of soil N availability[1]. In the recent years chemical methods involving estimation of NH_4-N extracted by acid or alkaline permanganate have received considerable attention[7,8,9]. Acid permanganate approach has been tested in this laboratory[4,5]. The results of the detailed study[5] with 35 soils indicated that if mineral N of soils is also included in the mineralizable N determined by acid permanganate extraction, the correlation of these N values with the plant uptake is much improved. Based on these data[5], a modification of the acid permanganate has been proposed herein with an objective to include the mineral N simultaneously during soil extraction and subsequent steam distillation of the extract.

Materials and methods

Thirty five-surface soils were used. Soil sampling and preparation procedures, and soil properties have already been reported[5]. Soil incubation and pot culture procedures have also been described in the same paper.

Modified acid permanganate method to include mineral N of soil

Pre-extraction of the soil with 1 *N* H_2SO_4, a step to remove mineral N of the soil in the original method[9] was omitted and the acid permanganate solution was directly employed for soil extraction. Solution of NaOH used for alkalization during steam distillation could take care of any NH_4-N either released by oxidative action of acid permanganate or exchanged by H^+ ions (exchangeable NH_4) of acid present in the extracting solution. To include NO_3-N portion of mineral N during steam distillation of the soil extract, Devarda's alloy was added.

i) Experiments with solutions To test the recovery of ($NH_4 + NO_3$) – N in the presence of acid permanganate, solutions containing known amounts of N (500 to 4000 µg/20 ml) were prepared using NH_4NO_3 salt. A 20 ml aliquot of each solution (at least in duplicate) was taken in distillation flask, 10 ml of 10% NaOH was added and mixed. One-g Devarda's alloy was then added and 50 ml distillate was collected in 5 ml of boric acid indicator mixture.

Table 1. The percent N recovery from NH_4NO_3 solutions in acid permanganate when modified method of $(NH_4 + NO_3)$ – N determination was employed using different quantities of 10% NaOH solution during steam distillation

20 ml aliquot steam distilled containing:	%N recovery	Means
a. *Using 10 ml of 10% NaOH solution*		
i) 500 μg N	97.3	
ii) 1000 μg N	96.7	
iii) 2000 μg N	97.8	
iv) 4000 μg N	97.9	97.4
b. *Using 15 ml of 10% NaOH solution*		
i) 500 μg N	98.0	
ii) 1000 μg N	97.7	
iii) 2000 μg N	97.7	
iv) 4000 μg N	98.2	97.9
c. *Using 20 ml of 10% NaOH solution*		
i) 500 μg N	97.3	
ii) 1000 μg N	98.7	
iii) 2000 μg N	98.6	
iv) 4000 μg N	97.2	98.0

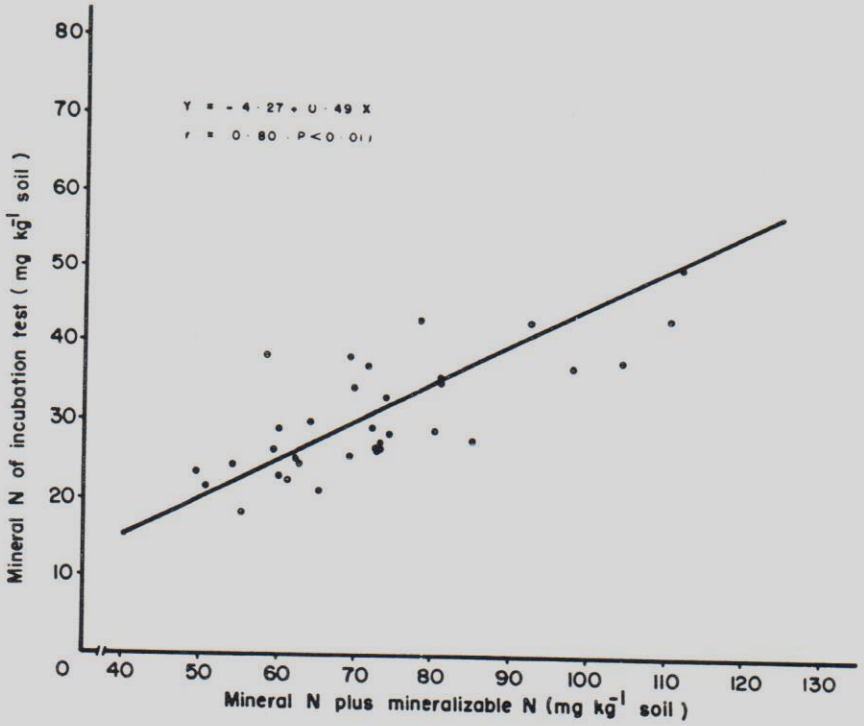

Fig. 1. Relationship between soil available N values estimated by modified acid permanganate method and mineral N produced by aerobic incubation of soils at 30 ± 1°C for 4 weeks.

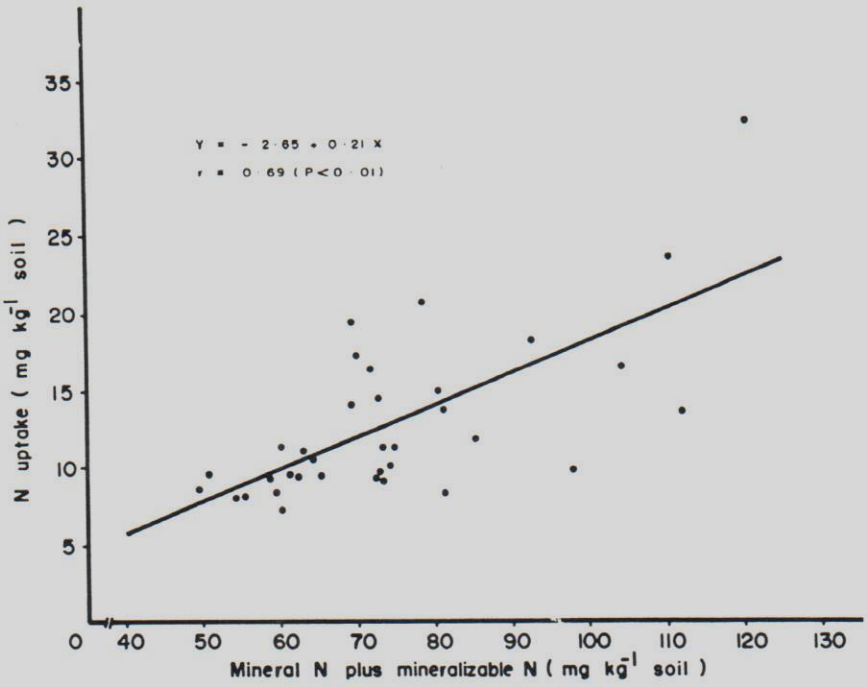

Fig. 2. Relationship between soil available N values estimated by modified acid permanganate method and N uptake by wheat plants.

The absorbed ammonia was titrated with standardized H_2SO_4 to determine the amount of NH_4-N[2].

ii) Experiments with soils Four-g samples of each soil (in triplicate) were shaken at room temperature for 1 h with 50 ml of 0.2*N* $KMnO_4$ in 1 *N* H_2SO_4 and then filtered. (NH_4 + NO_3) – N in 20 ml aliquots was determined by steam distillation as described above. The results obtained were correlated with the mineral N of incubation test and plant uptake.

Results and discussion

Solutions

To neutralize the effect of 20 ml of 1 *N* H_2SO_4 in 20 ml aliquot taken for distillation, 8 ml of 10% NaOH solution (2.5 *N*) was sufficient. Two-ml of this NaOH solution added in excess was found adequate to alkalize the solution for NH_4-N determination, and its reaction with Devarda's alloy for creating reducing conditions for NO_3. It was observed that addition of 1 g Devarda's alloy in the presence of excess alkali was enough to neutralize the oxidative effect of permanganate and to create reducing conditions for NO_3. For the reduction of NO_3 to NH_4, Devarda's alloy is a commonly used reducing agent. Sahrawat and Burford[7] also modified the alkaline permanganate method by simply adding Devarda's alloy during steam distillation to include soil NO_3 in the available N pool. The average (NH_4 + NO_3) – N recovery determined from the tested solutions with the modified method was 97.4% (Table 1).

As small amount of acid in the extraction solution is utilized during its reaction with soil, therefore, it is probable that in the aliquots of soil extracts being distilled, the quantity of 10% NaOH might effect N recovery. Therefore, while conducting experiments with solutions, the quantity of 10% NaOH solution used for alkalization was increased. The results showed that the alkali addition even upto 20 ml did not affect the N recovery (Table 1).

Soils

Residual mineral N plus mineralizable N in soils determined by the modified acid permanganate method ranged from 49.6 to 120.8 mg kg^{-1} soil. The correlation of these results with the mineral N of incubation test has been shown in Fig. 1 which is quite high ($r = 0.80$, $P < 0.01$). In our previous study[5] it was found that the correlation of the unmodified method with the incubation test was quite poor ($r = 0.38$, $P < 0.05$). Comparatively high correlation of the modified method with the incubation method indicated that it could provide a better index of soil N availability.

The correlation coefficient of the results obtained by the modified method with the N uptake by wheat plants was 0.69 ($P < 0.01$, Fig. 2). Previously[5] when soil mineral N was determined separately and then added to the N extracted by the unmodified method, the correlation of the results thus obtained with N uptake by wheat plants was found to be 0.66 ($P < 0.01$). A close agreement between these correlation coefficients *i.e.* 0.69 in the present study and 0.66 in the previous study[5] further shows the suitability of the modified method for simultaneous determination of residual mineral N and mineralizable N in soils.

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