

Evaluation of alkaline permanganate method and its modification as an index of soil nitrogen availability

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Summary To find out a rapid and reliable procedure for estimating soil available nitrogen (N), the standard alkaline-permanganate extraction and its modification to include soil NO_3 were evaluated. The N values obtained with the standard method showed a poor correlation with the mineral N of incubation test and plant uptake ($r = 0.36$ and 0.37 respectively $P < 0.05$ in both the cases) whereas the results obtained with the modified method gave highly significant correlations ($r = 0.84$ and 0.76 respectively, $P < 0.01$ in both the cases). The data supplied further verification of the modified alkaline-permanganate method for assessing N availability in soils.

Introduction

Biological methods involving soil incubation have generally been accepted as the most reliable methods for estimating available N in soils¹. However, these methods are time consuming and, therefore, research efforts have long been made to find out a chemical method that could provide a reliable index of soil-N availability⁶. In recent years chemical methods involving the estimation of $\text{NH}_4\text{-N}$ released by treating the soil with acid-or alkaline-permanganate have received considerable attention^{2,4,6,8}. In order to improve the performance, various modifications of acid-or alkaline-permanganate method have been evaluated^{3,6}. Stanford⁶ while testing the general validity of alkaline-permanganate method obtained less precise and reliable results than the acid-permanganate method. However, the alkaline-permanganate method is being widely used in India for assessing available N in soils⁵. In view of such a controversy, the present studies were designed to evaluate the alkaline permanganate method and its modification (recently proposed by Sahrawat and Burford⁵) in relation to the soil incubation test and plant uptake.

Materials and methods

The present studies were carried out on 35-surface soils previously used to evaluate acid permanganate extraction⁴. Soil sampling and preparation procedures, soil properties and the methods used to analyse the soils have already been given⁴. Procedures to carry out the soil incubation and pot culture studies have also been described in the same paper.

Alkaline-permanganate methods used for soil extraction

i) *Standard method.* The extraction procedure was almost the same as described by Sahrawat and Burford⁵. A quantity of 4 g soil sample was placed in 500 ml flat bottom flasks and 20 ml of 0.32% KMnO_4 solution and 20 ml of 2.5% NaOH solution were added. The flask was then connected to the distillation unit and 50 ml of the distillate was collected in 5 ml of boric-acid indicator mixture. As it was established by Sahrawat and Burford⁵ that the

addition of water to the contents of the flask before connecting it to the distillation unit caused no significant change in the amount of distillable N, therefore, no additional water was used at the time of extraction. The absorbed ammonia was titrated with 0.005 N H_2SO_4 to determine the amount of NH_4 -N.

ii) *Modified method to ensure the inclusion of soil nitrate.* To estimate NO_3 -N simultaneously, modification-2 of the alkaline-permanganate method proposed by Sahrawat and Burford⁵ was followed. The modification involved the distillation as in the standard method until 50 ml of distillate was collected, then addition of 0.5 g Devarda's alloy followed by further distillation until another 50 ml was collected. Sahrawat and Burford⁵ used this two-stage distillation because they observed that the action of the Devarda's alloy added to reduce NO_3 to NH_4 was found to interfere with the oxidation of organic N by alkaline permanganate.

The standard as well as the modified alkaline-permanganate methods were employed on triplicate samples of each soil.

Results and discussion

Standard alkaline-permanganate method

Ammonium-N extracted by the standard alkaline-permanganate method ranged from 39.1 to 72.9 mg kg^{-1} soil. The correlation coefficients of N values obtained by this method vs. mineral N of soil incubation for 4 weeks and plant uptake were 0.36 and 0.37 respectively ($P < 0.05$ in both the cases) which were quite poor. These results indicated that this method may not provide a good index of soil available N. Stanford⁶ reported a number of earlier studies with alkaline-permanganate extraction of soil including revisions of the method. He also tried several concentrations of NaOH and $KMnO_4$ in various combinations. His conclusion was that the alkaline-permanganate methods thus far reported by various investigators, as well as modifications evaluated in his study provide a less precise and reliable basis for predicting N availability.

The alkaline-permanganate method that only measures NH_4 -N released from soil organic matter in addition to the NH_4 -N already present in soils, does not include NO_3 -N because this has an oxidizing action and would not reduce NO_3 -N to NH_4 -N. As considerable amounts of NO_3 -N may accumulate under upland conditions, it becomes an important aspect in the alkaline-permanganate method to be considered. Some other investigators⁵ also thought that the poor correlation with the plant uptake may be due to the inability of the alkaline-permanganate method to include soil NO_3 -N. In view of that they proposed a modification of the method for estimating NO_3 -N of the soil simultaneously.

Modified alkaline-permanganate method

When by a modified method⁵ soil NO_3 was estimated alongwith the NH_4 -N extracted by the alkaline permanganate, the available N values ranged from 43.7 to 121.8 mg kg^{-1} soil. The correlation of these N values with the mineral N of soil incubation for 4 weeks has been shown in Fig. 1 which is quite high ($r = 0.84, P < 0.01$). This high correlation clearly indicated that the modified alkaline-permanganate method could provide a good index of soil N availability. The correlation of the available N values estimated by the modified method with the N uptake by wheat plants shown in Fig. 2 was also quite high ($r = 0.76, P < 0.01$). These data further verify the reliability of the modified method for available N estimation.

The results of the current studies support the modified permanganate method for predicting available soil N and reflect the importance of NO_3 -N while devising a method for available N in soil. Significance of NO_3 -N in the available N pool has been demonstrated by several workers^{5,7}.

In our previous study⁴ it was found that when mineral N of the soil was included in the mineralizable N extracted by the acid-permanganate method, the correlation of these N values with the plant uptake in comparison to the other conventional methods tried, was better

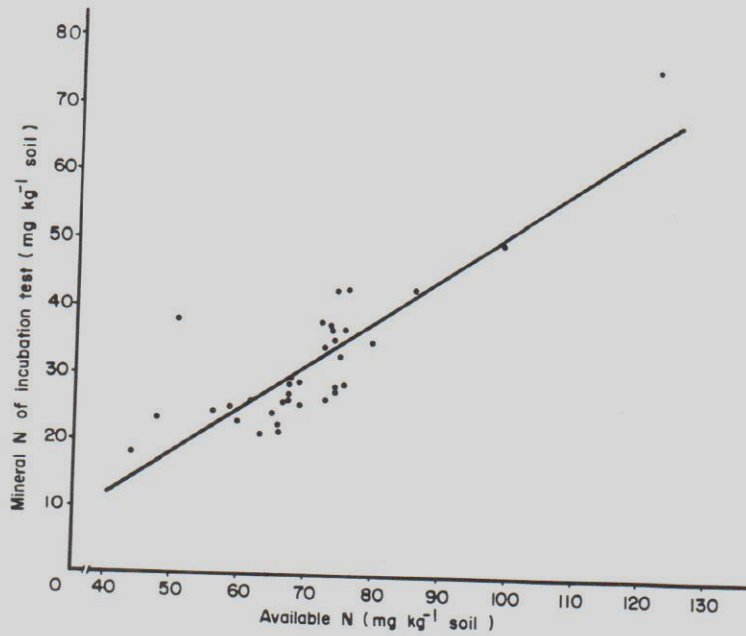


Fig. 1. Relationship between soil-available N values estimated by modified alkaline-permanganate method and mineral N produced by aerobic incubation of soils at $30 \pm 1^\circ\text{C}$ for 4 weeks.
 $y = -14.41 + 0.66x$
 $r = 0.84$ ($P < 0.01$).

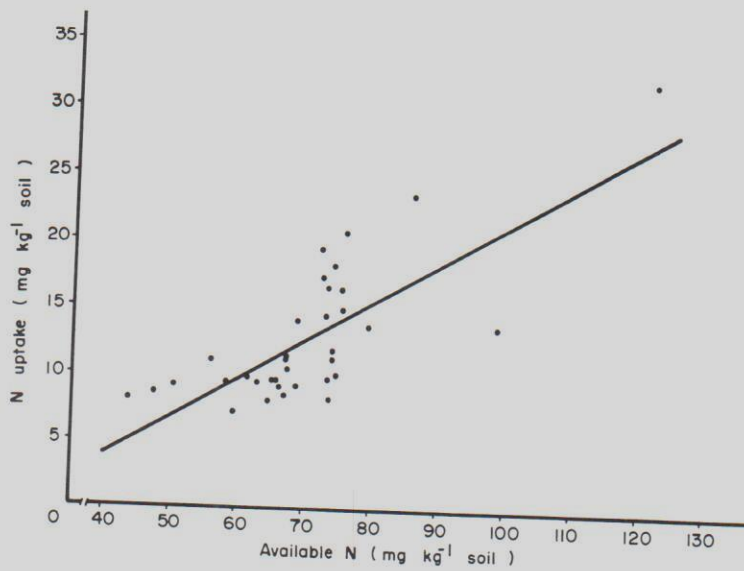


Fig. 2. Relationship between soil-available N values estimated by modified alkaline-permanganate method and N uptake by wheat plants.
 $y = -7.74 + 0.29x$
 $r = 0.76$ ($P < 0.01$).

($r = 0.68$ and 0.66 , $P < 0.01$ in both the cases). A modification of the acid-permanganate method was then proposed³ to estimate the mineral N simultaneously and a similar type of correlation coefficient obtained was 0.69 ($P < 0.01$). Compared with these correlation coefficients (0.68 , 0.66 and 0.69), the correlation between modified alkaline-permanganate method and the plant uptake was even higher ($r = 0.76$, $P < 0.01$). From these comparisons it appears that the modified alkaline-permanganate method could provide a relatively better index of available N than the acid-permanganate method modified to include mineral N. Moreover, the modified alkaline-permanganate method that directly involve the extraction of the soil with alkaline permanganate during steam distillation could save extra labour and time required in the acid-permanganate method for shaking the soil with the extracting solution for 1 h followed by filtration and pipetting of the extract aliquot to be employed for steam distillation.

The overall results of the present studies help to infer that the modified alkaline-permanganate extraction is relatively a more reliable, simple and rapid chemical method and deserves more consideration as a routine test for available N in soils.

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