Pakistan J.Sci.Ind.Res., Vol. 26, No.2, April 1983

MINERALIZABLE NITROGEN AS AN INDEX OF SOIL NITROGEN AVAILABILITY

F. Hussain and K.A. Malik

Soil Biology Division, Nuclear Institue for Agriculture & Biology, Faisalabad

(Received , March 27, 1982)

Ammonium N released by oxidation with two concentrations of acid permanganate extraction solution was measured in 10 soils. Ammonium N released by 0.1 $\underline{N}$ $KMnO_4$ in 1 $\underline{N}$ H_2SO_4 significantly correlated with the N uptake by wheat plants as well as with the amount of mineral N released during an incubation test.

The results of the study bring out the usefulness of a simple soil test for mineralizable N, an index of N availability.

INTRODUCTION

Practically all N in surface soils is organically combined and, therefore, cannot be utlized directly by plants.[1] Some of it (usually 1 to 3 %) is mineralized by microbial process during the crop growing season and this provides a substantial amount of plant available N[2]. Due to the obvious difficulties in assessing fertilizer requirements, this mineralizable N has more often been neglected leading to unjudicious applications of fertilizer N. To improve assessment of N fertilizer requirements there is need to find a method that will provide a satisfactory index of soil N availability and will permit reasonably accurate prediction of the amount of fertilizer N required to produce a desired crop yield.

Methods currently available for assessment of potentially available soil N for crop growth are those involving soil incubations under controlled laboratory conditions [2]. These incubation methods, though reliable, are time consuming and laborious.

Soil scientists have long searched for a chemical method that would provide a reliable index of soil N availability [2,3].Chemical methods involving determination of total Nitrogen (mineral N and Organic matter) have been found to be of little value [4,5].Smith and Stanford[6] proposed autoclaving soil in 0.01 M $CaCl_2$ and then determining the NH_4-N released. They found that distillable NH_4-N released during 16 hr of autoclaving correlated well with N mineralized for a broader range of soils, but certain calcareous soils did not conform to the general relationship[6,7].Methods involving estimation of the amount of ammonium released by treatment of soil with acid or alkaline reagents have received considerable attention [2]. Shihata[8] and Truog [9] were the first to propose NH_4-N, released by boiling the soil sample with alkaline permanganate, as a chemical index of soil N availability. Since 1953, a number of studies with alkaline permanganate extraction of soils have been reported including several revisions of methods first proposed. Standford[10] evaluated the alkaline permanganate method and its modification and concluded that the modified as well as alkaline permanganate methods thus far reported by various investigators offer less precise and reliable results. Stanford and Smith[11], therefore, proposed the use of acid permanganate extraction as a new chemical index of soil N availability.

As far as the authors are aware, little work has been done in Pakistan on mineralizable N and its estimation. The present paper deals with the correlation studes of NH_4-N released by acid permanganate, as a soil test for N availability, with the amount of N released in an incubation test and with N uptake by wheat plants.

MATERIAL AND METHODS

Surface soils (0-5 cm) representative of 10 soil series (5 each of upland and lowland) were collected from Gujranwala and Shekhupura districts of the Punjab. The soils were air-dried and groun to pass through a 2-mm sieve. Estimation of mineralizable nitrogen by the incubation and the chemical methods and its correlation with N uptake by wheap plants was carried out as under:

Incubation Method: 100-g portions of the soil samples were taken in flat-bottomed plastic vessels with lids having a central hole to provide gaseous exchange. Soil samples in quadruplicate were brought to their respective field capacities by the addition of distilled water and then incubated

at 30 ± 1°C for 2,4,6 and 8 weeks. Soil moisture was maintained at field capacities by addition of distilled water at frequent intervals during the course of the experiment. For each time interval there was a separate set of incubated soils. At the end of each incubation period, the soils in the plastic vessels were thoroughly mixed and subsamples were extracted with 2 $\underline{N}$ KCl. Inorganic N in the extracts was determined by steam distillation with Devarda's alloy and MgO [12].

Extraction Procedure: Freshly prepared 0.05 and 0.1$\underline{N}$ $KMnO_4$ in 1$\underline{N}$ H_2SO_4 were used for extraction of the various soil samples.

2-g soil samples (in triplicate) were taken in centrifuge tubes and shaken with 50 ml of 1 $\underline{N}$ H_2SO_4 for 1 hrat room temperature. After centrifugation, the supernatant was discarded and soil residue was then shaken for another 1 hr. with 50 ml of acid $KMnO_4$ solution. After centrifugation, the supernatant was collected and analysed for NH_4-N by steam distillation using NaOH as the alkalizer [13]

Pot Culture: Triplicate 1.5 kg subsamples of each soil were filled in polythene lined plastic pots. Soils in the pots were brought totheir respective field capacities by the addition of distilled water. Seven seeds of wheat *(Triticum aestivam* L., cv. Sandal) were sown in each pot and the stand thinned to 3 seedlings thereafter. Moisture of soils in the pots was maintained at their respective field capacities by daily addition of distilled water throughout the plant growth period. The plants were harvested 40 days after germination and rinsed thoroughly indistilled water. Plant tops were dried inan oven at 70°C for 58 hr. Total N in the ground plant material was determined by Kjeldahl method.

RESULTS AND DISCUSSION

Residual plus mineralizable N after 8 weeks of incubation ranged from 38.3 to 102.9 ppm (Fig.1). A general increase in net mineral N accumulation with passage of time indicated that more N could be released if the soils would have been further incubated under the conditions which promoted the mineralization of soil N. The magnitude of mineralization was found to be maximum in Kamoke series while it was minimum in case of Pindorian (M.T.) series. It is evident from Table 1 that N mineralization was mainly dependent on soil organic matter content of the soils as the results of incubation test showed a positive correlation with the organic matter content of the soils but not with their other properties.

The data of the present incubation test revealed that these soils have sufficient store of mineralizable N which could contribute substantially in meeting crop N requirement and help in discouraging the unjudicious applications of fertilizer N.

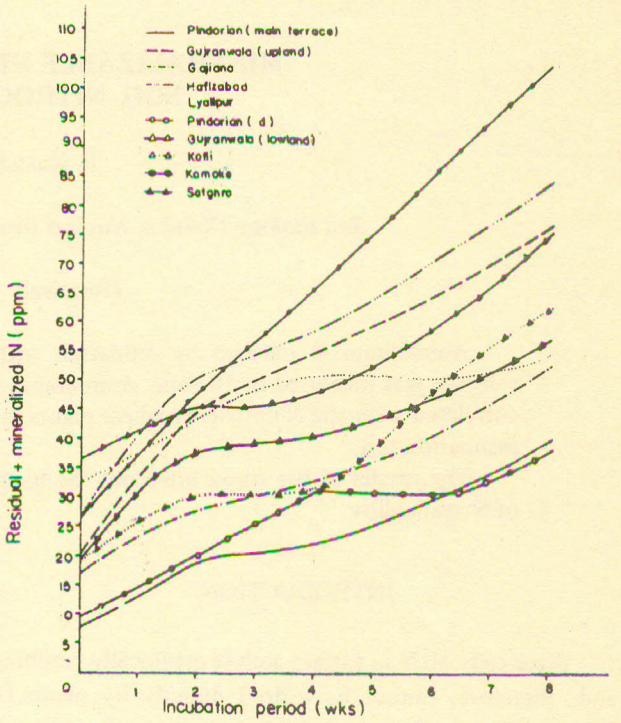

Fig. 1. Nitrogen mineralization in 10 soils incubated for different time intervals at 30±1°C and field capacity moisture level.

The results of NH_4-N estimation in soils based on chemical extractionwith two concentrations of acid $KMnO_4$ are summarized in Table 2. Extraction with 0.1 $\underline{N}$ $KMnO_4$ in 1 N H_2SO_4 released NH_4-N almost double in many soils as compared to the extraction with 0.05 $\underline{N}$ $KMnO_4$ in 1 $\underline{N}$ H_2SO_4. Results indicated that a considerable fraction of soil organic matter is succeptable to acid $KMnO_4$ oxidation at room temperature. As the soil of some of the series used i.e. Kamoke, Gujranwala (upland) and Hafizabad were previously sown to berseem *(Trifolium alexandrinum* L.,) the higher concentration of acid permanganate extracted proportionately more NH_4-N. Stanford and Smith[11] tried similar two concentrations of acid permanganate and found that the NH_4-N released by both the concentrations correlated well with the potentially mineralizable N in soils. In the present study however higher concentration of acid permanganate seemed to be more specific in oxidizing soil organic matter fraction susceptable to mineralization. This is clear because NH_4-N extracted by 0.1 $\underline{N}$ $KMnO_4$ correlated with the amount of inorganic N found in soils by the incubation method (Table 3).

The contribution of mineralizable N in meeting N requirement of wheat plants is apparent from Table 4. A

positive and significant correlation was also found between NH_4-N released by 0.1 $\underline{N}$ $KMnO_4$ and total N uptake by wheat plants (Table 5).

The overall results of the present study revealed that NH_4-N released by the oxidative action of 0.1 $\underline{N}$ $KMnO_4$ could be used for the estimation of plant available soil N

Table 1. Relation between soil properties and mineral N (residual + mineralizable) released from 10 soils after incubation for different time intervales at 30 ± 1°C and field capacity moisture level.

Soil property	Correlation coefficients				
	0 week	2 weeks	4 weeks	6 weeks	8 weeks
1. Clay	0.2096NS	0.2479NS	0.2632NS	0.5003NS	0.5622NS
2. pH_s	- 0.0953NS	- 0.0956NS	- 0.0059NS	- 0.2037NS	- 0.2326NS
3. $EC_e x10^3$	0.6890*	0.3483NS	0.1768NS	0.1469NS	0.2099NS
4. $CaCO_3$ equi.	0.4880NS	0.1561NS	0.0772NS	0.0811NS	0.1639NS
5. O.M.	0.3987NS	0.6003NS	0.5647NS	0.7476*	0.7663**
6. Total N	0.0670NS	0.0916NS	0.0948NS	0.2324NS	0.2543NS
7. Na HCO_3-extractable P	0.4316NS	0.2036NS	0.0849NS	0.1068NS	0.1703NS

* Significant at P 0.05 **Significant at P 0.01 NS Non-significant

Table 2. Oxidative release of NH_4-N from soils during extraction with 0.05 and 0.1 $\underline{N}$ $KMnO_4$ in 1$\underline{N}$ H_2SO_4 for 1 hour at room temeprature

Soil series	NH_4-N (ppm) released by acid permanganate oxidation		
	0.05$\underline{N}$ $KMnO_4$ in in H_2SO_4	0.1$\underline{N}$ $KMnO_4$ in in H_2SO_4	Means
UPLAND			
1. Pindorian (M.T.)	46.8	67.6	57.18
2; Gujranwala	55.5	96.7	76.13
3. Gajiana	43.9	72.2	58.07
4. Hafizabad	56.1	89.7	72.93
5. Lyallpur	65.5	75.7	70.62
LOWLAND			
6. Pindorian (d)	33.4	57.7	45.52
7. Gujranwala	60.2	92.7	76.45
8. Kotli	43.3	79.3	61.27
9. Kamoke	55.0	93.8	74.42
10. Satghra	43.3	89.7	66.52
Means	50.31	81.52	
Means	LSD (0.05)	LSD (0.01)	
Concentration	4.75	6.36	
Soil	10.62	14.22	
Concentration x soil	NS	NS	

Table 3. Relation bewteen NH_4-N released during extraction with two concentrations of acid permanganate solution with mineral N (residual + mineralizable) found in soils after incubating for different time intervales at 30 ± 1°C and field capacity moisture level.

Acid permanganate Concentration	Correlation coefficients				
	0 week	2 weeks	4 weeks	6 weeks	8 weeks
1. 0.05N $KMnO_4$ in 1 N H_2SO_4	0.4723^{NS}	0.6481^{*}	0.6004^{NS}	0.4922^{NS}	0.3840^{NS}
2. 0.1 N $KMnO_4$ in 1 N H_2SO_4	0.6010^{NS}	0.8542^{**}	0.7563^{*}	0.8269^{**}	0.8241^{**}

* Significant at P 0.05 ** Significant at P 0.01 NS Non-significant

Table 4. Effect of residual plus mineralizable soil N on dry matter, N concentration and N uptake by wheat.

Soil series	T.D.M. (g/pot)	Total N (%)	Total N uptake (mg/pot)
UPLAND			
1. Pindorian (M.T)	0.4198	3.152	13.196
2. Gujranwala	0.9123	2.625	23.843
3. Gajiana	0.5124	4.060	20.790
4. Hafizabad	0.7996	3.979	31.712
5. Lyallpur	1.0799	3.174	33.692
LOWLAND			
6. Pindorian (d)	0.9155	2.170	19.886
7. Gujranwala	1.0505	3.728	38.877
8. Kotli	0.9054	2.707	24.425
9. Kamoke	1.4061	2.648	36.674
10. Satghra	2.1027	2.287	47.710

Table 5. Relation of acid $KMnO_4$ – extractable N with dry matter, N concentration and N uptake by wheat.

Acid $KMnO_4$ Concentration	Correlation coefficients		
	T.D.M. (g/pot)	Total N (%)	Total N uptake (mg/pot)
1. 0.05 *N* $KMnO_4$ in 1 *N* H_2SO_4	0.0368^{NS}	0.4309^{NS}	0.3908^{NS}
2. 0.1 *N* $KMnO_4$ in 1 *N* H_2SO_4	0.4670^{NS}	0.0966^{NS}	0.6512^{*}

* Significant at P 0.05 NS Non-significant.

as the results of this concentration correlated well with the results of the incubation test. However, the correlation was comparatively poor ($r=0.65$, $P < 0.05$) with total N uptake by wheat plants.

The present study though of a preliminary nature, offers an opportunity for further assessing the possible utility of acid permanganate approach as a routine test for measuring nitrogen availability in a large number of soils.

Acknowledgement: The authors wish to thank Ch. M. Rafiq, Director Soil Survey of Pakistan, Lahore for providing assistance in soil sampling and M/s. M.A. Kauser and F. Azam, Scientific Officer of this Institute for critically reviewing the manuscript.

REFERENCES

1. J.M. Bremner, in *Methods of Soil Analysis, Part II,* C.A. Black(ed.), Agronomy **9**, 1238 (1965).
2. J.M. Bremner, in *Methods of Soil Analysis, Part II,* C.A. Black(ed.), Agronomy, **9**, 1324 (1965).
3. G.Stanford and J.O.Legg, Soil Sci., **105**,320 (1968).
4. G.W. Harmsen and D'A. Van Schreven, Advan. Agron. **7**, 299 (1955).
5. F.E. Allison, Agr. Chem., **11(No. 4)**, 46; 139 (1956).
6. S.J. Smith and G. Stanford, Soil Sci., **111**, 228 (1971).
7. G. Stanford and S.J. Smith, Soil Sci., **122**, 71 (1976).
8. M.M. Shihata, Ph.D., thesis, University of Wisconsin (1953).
9. E. Truog, Commer. Fert., **88**, 72 (1954).
10. G. Stanford, Soil Sci., **126**, 244 (1978).
11. G. Stanford and S.J, Smith, Soil Sci., **126**, 210 (1978).
12. J.M. Bremner and D.R. Keeney, Analytica Chim. Acta, **32**, 485 (1965).
13. J.M. Bremner, in *Methods of Soil Analysis, Part II* C.A. Black (ed.) Agronomy, **9**, 11 79 (1965).