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Comparative evaluation of biological and chemical methods to determine nitrogen mineralisation coefficient of tropical rice soils

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ABSTRACT

Two anaerobic incubation methods (30^0 C for 2 weeks; 40^0 C for 1 week) and five chemical methods, based on ammonium released by the action of hydrogen peroxide (H_2O_2) , alkaline permanganate, acid permangnate, acid dichromate, and dilute sulphuric acid, were used to determine nitrogen mineralisation coefficient (fraction of total nitrogen released as mineral N) of 39 diverse Philippine rice soils having a wide range in organic C, total N, and other properties. Hydrogen peroxide oxidation method gave the highest average nitrogen mineralisation coefficient (26.9%) and highest average nitrogen mineralisation coefficient (26.9%) and acid dichromate extraction the least (2.9%). Anaerobic incubation methods gave average nitrogen mineralisation coefficients of 4.2 (30^0 C, 2 weeks) and 5.1% (40^0 C, 1 week), respectively.

It is proposed that for the comparative evaluation of chemical and biological methods for determining nitrogen mineralisation coefficient of soils, the criterion of 'relative nitrogen mineralisation coefficient', which is the ratio of nitrogen mineralisation coefficient obtained by a chemical method to that determined by a biological method should be considered.

Assessment of nitrogen supplying capacity of soils is an important component of research for efficient and judicious use of fertiliser nitrogen . Several chemical and biological methods have been proposed for assessing the pool of potentially mineralisable nitrogen that may be made available for crop growth by mineralisation of soil organic nitrogen during the growing season (Keeney 1982, Stanford 1982, Sahrawat 1983). Biological methods, involving anaerobic and aerobic incubation methods though time consuming, are useful for assessing soil nitrogen availability (Keeney 1982).

Chemical methods that selectively extract the fraction of organic nitrogen that contributes to biological mineralisation of soil organic nitrogen can ideally be used for assessing mineralisable nitrogen in soil (Saharawat 1983). However, in practice, it is rather difficult with a simple chemical index to simulate the biological process of soil nitrogen mineralisation. An alternative approach would be to rationalise the nitrogen mineralisation coefficient determined by a chemical method by comparing it to that obtained by a biological method. Here, nitrogen mineralisation coefficient is defined as the fraction of total soil nitrogen released as mineral nitrogen during biological mineralisation or when determined by a chemical method, and is expressed as per cent of total soil nitrogen.

The objective of the work reported in this communication was to determine nitrogen mineralisation coefficient of 39 diverse Philippine soils using two biological and five chemical methods, and to discuss its relevance in assessing the nitrogen supplying capacity of soils. Furthermore, the concept of 'relative nitrogen mineralisation coeffient determined by a chemical method to that obtained by a biological method, is advanced for rationlising the deter-

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mination of nitrogen mineralisation coefficient of soils by chemical methods.

MATERIALS AND METHODS

Soils. Soils used were 39 surface (0-15 cm) samples collected shortly before the study from different rice growing regions of the Philippines. The soil samples were air dried and ground to pass through a 2-mm screen before use.

Physical and chemical properties of the soils and the methods of analysis have been described in detail previously (Sahrawat 1982). Range and mean values of some important soil characteristics given in Table 1, show that the soils had a wide range in texture, pH, cation exchange capacity (CEC), organic C, total nitrogen and C/N ratio.

Table 1. *Range and mean values of some characteristics of 39 soils used*

Soil characteristics	Range	Mean
pH (1 : 1 H_2O)	4.3-7 9	5.74
CEC (m.mol kg^{-1})	70-513	310
Clay (%)	12-71	44
Organic C (%)	0.63-5.46	1.61
Total N (mg kg^{-1})	600-6000	1544
C/N ratio	7.9-15.9	11.01

Methods used for determining mineralisable nitrogen. The methods used for determining mineralisable nitrogen in soils have been described in detail earlier (Sahrawat 1982). A brief outline is provided below.

Anaerobic incubation methods. (1) Anaerobic incubation of soil samples under waterlogged conditions at 30° for 2 weeks (Waring and Bremner 1964), and (2) Anaerobic incubation of soil samples under waterlogged conditions at 400°C for 1 week (Sahrawat 1982).

The anaerobic incubation method of Waring and Bremner (1964) was modified in that the ammonium released during anaerobic incubation was measured on extracts obtained by extracting the soil samples with 2 M KCl as suggested by Sahrawat and Ponnamperuma (1978) and described previously (Sahrawat 1982).

Chemical indexes. The details of the methods used for measuring mineralisable nitrogen given earlier (Sahrawat 1982) are briefly described here.

(1) Hydrogen peroxide (H_2O_2) oxidation method : The method described by Saharawat (1982) was used to measure the ammonium released from soils by dilute H_2O_2 oxidation.

(2) Alkaline permanganate digestion method : The method described by Subbiah and Asija (1956) was followed with minor modifications (Sahrawat 1982).

(3) Acid permanganate extraction method, : The method of Stanford and Smith (1978) as described by Sahrawat (1982) was followed.

(4) Acid dichromate extraction method : The ammonium released from soil samples by acid dichromate (0.02 M $K_2 Cr_2 O_7$ in 0.5 M H_2SO_4) extraction was measured as described by Sahrawat (1982).

(5) Dilute sulphuric acid (0.5 M H_2SO_4) extraction method : The ammonium released during extraction of soil samples with 0.5 M H_2SO_4 was measured as described by Sahrawat (1982).

RESULTS AND DISCUSSION

The soils used provided a wide range in mineralisable nitrogen as determined by two anaerobic incubation methods and five chemical

Table 2. *Range and mean values of mineralisable nitrogen in soils determined by biological and chemical methods*

Method	Mineralisable N (mg/kg)	
	Range	Mean
Anaerobic incubation (30^0 C, 2 weeks)	17-428	78
Anaerobic incubation (40^0C, 1 week)	13-522	98
Hydrogen peroxide oxidation	26-1093	238
Alkaline permanganate digestion	111-397	193
Acid permanganate extraction	42-139	80
Acid dichromate extraction	11-110	40
Dilute sulphuric acid extraction	7-77	37

methods (Table 2). The mean nitrogen mineralisation coefficient of soils also varied greatly (2.9 to 26.9%) (Table 3). The highest mean nitrogen mineralisation coefficient (value give nin parenthesis) was obtained with H_2O_2 oxidation method (26.9%) followed by alkaline permanganate digestion (15.5%), acid permanganate extraction (6.7%), dilute H_2SO_4 extraction (3.1%) and acid dichromate extaraction (2.9%) methods.

The range and mean and values of relative nitrogen mineralisation coefficient of soils given in Table 4 show that the mean relative nitrogen mineralisation coefficient varied widely (0.70 to 6.5) .

Table 3. *Range and mean values of nitrogen mineralisation coefficient of soils determined by biological and chemical methods*

Method	N mineralisation coefficient[1] (%)	
	Range	Mean
Anaerobic incubation (30^0C, 2 weeks)	2.15-10.71	4.2
Anaerobic incubation (40^0C, 1 week)	1.62-10.83	5.1
Hydrogen peroxide oxidation	2.90-50.86	26.9
Alkaline permanganate digestion	6.61-28.37	15.5
Acid permanganate digestion	2.30-11.67	6.7
Acid dichormate extraction	1.04-6.17	2.9
Dilute sulphuric acid extraction	1.00 = 6.00	3.1

[1]Nitrogen mineralisation coefficient, % $= \frac{\text{Mineral} - \text{N released}}{\text{Total N}} \times 100$

Table 4. *Range and mean values of relative nitrogen mineralisation coefficient of soils*[1]

Method	Range	Mean
Hydrogen peroxide oxidation	0.91-18.77	6.46
Alkaline permanganate digestion	0.93-9.46	3.73
Acid permanganate extraction	0.32-4.12	1.60
Acid dichromate extraction	0.21-1.68	0.70
Dilute sulfuric acid extraction	0.13-2.00	0.74

[1] Relative to anaerobic incubation method (30^0C, 2 weeks)

$$\text{Relative nitrogen mineralisation coefficient} = \frac{\text{N mineralisation coefficient determined by chemical method}}{\text{N mineralisation coefficient determined by anaerobic incubation method}}$$

As noted in "Introduction" for rationalising the estimate of nitrogen supplying capacity of soils by chemical methods, coefficient obtained by a chemical method to that obtained by a biological method (aerobic or anaerobic incumbation) should be considered. The ratio of nitrogen mineralisation coefficient determined by a chemical method to that determined by a biological method, termed 'Relative nitrogn mineralisation coefficient' is proposed as a criterion for comparative evaluation of chemical and biological methods for assessing the nitrogen supplying capacity of soils.

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