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# NITROGEN SUPPLYING ABILITY OF SOME PHILIPPINE RICE SOILS

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KEY WORDS

Direct distillation Dry matter $H_2O_2$-oxidisable N Mineralizable N N uptake Organic carbon Soils Total N

## SUMMARY

The nitrogen-supplying power of eight Philippine rice soils was measured by consecutively growing six crops of IR 32 rice under flooded conditions in a greenhouse pot experiment. The dry matter yields or nitrogen uptake of rice were found to be highly positively correlated with the organic carbon and the total nitrogen contents of the soils, as well as with the amounts of ammonium released during an anaerobic incubation test at 30°C for 2 weeks.

The results of the study bring out the usefulness of simple tests like organic carbon content and total nitrogen content of soils for predicting the nitrogen-supplying power to lowland rice.

## INTRODUCTION

The recent fertilizer shortage and the need for efficient use of fertilizer nitrogen have stimulated interest in the development of methods for assessing the nitrogen-supplying capacity of soils and thus for estimating fertilizer nitrogen requirements for crops.

Among the numerous methods proposed for assaying the nitrogen-supplying capacity of soils are chemical procedures like determination of organic carbon or total nitrogen content and oxidation of the soil organic matter by certain chemical agents. It has also been recognized that the incubation methods, though time consuming, are quite reliable in predicting the nitrogen supplying power of soils. Bremner[4] and Robinson[9] have reviewed the different methods proposed for soil nitrogen availability indexes.

According to Lopez and Galvez[7] and Ponnamperuma[8], the amount of ammonia released by anaerobic incubation of soils should be a good measure of

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available nitrogen in flooded soils. Many researches[6,12,13,15] used ammonia released during incubation at 30 °C for 2 weeks or at 40 °C for 6 days as an index of nitrogen availability to rice. Chang[5] suggested that the initial $NH_4^+$-N plus the ammonia released after waterlogged incubation for 1 week gave the best assessment of the soil nitrogen availability to rice.

Similarly, several chemical methods have been proposed for predicting nitrogen availability, and they include measurement of total nitrogen or organic carbon contents of soils[1,14] or of ammonia or total organic nitrogen extracted by acid or alkaline reagents[4].

The main objective of this work is to present evidences to show that simple determinations like organic carbon or total nitrogen content of soils could be conveniently employed for assaying the nitrogen supplying capacity of some Philippine lowland rice soils. The laboratory incubation method was also used for predicting the soil nitrogen availability to rice in a greenhouse under flooded conditions. A simple chemical method, based on the exidative release of ammonium from soil organic matter by hydrogen peroxide treatment, has also been tested as an index for nitrogen availability to rice.

## MATERIALS AND METHODS

The eight surface soil samples from rice fields used in this study had a range in pH, organic matter, texture, and total nitrogen contents (Table 1). The soils were air-dried and ground to pass through a 5-mm sieve before use in the greenhouse test. For laboratory studies, the soil samples were ground to pass through a 2-mm screen. The pH of a 1:1 soil-to-water suspension was measured by a glass electrode. Organic matter was determined by the method of Walkley and Black[16] and total nitrogen by that of Bremner[2].

Table 1. Analysis of soils used

| Soil | pH | Organic carbon (%) | Total N (%) |
|---|---|---|---|
| Buenavista clay loam | 6.3 | 0.64 | 0.070 |
| Calalahan sandy loam | 3.4 | 1.57 | 0.110 |
| Paete clay loam | 5.3 | 6.04 | 0.350 |
| Luisiana clay | 4.8 | 1.50 | 0.175 |
| Maahas clay | 6.5 | 0.93 | 0.120 |
| Pila clay | 7.5 | 2.27 | 0.185 |
| Quingua silty loam | 6.5 | 1.28 | 0.115 |
| Lipa loam | 7.0 | 2.50 | 0.190 |

## *Greenhouse procedure*

To determine the nitrogen-supplying capacity of the soils, six crops of IR 32 rice were grown for 6 weeks each, under flooded conditions in pots (10 kg soil) in a greenhouse. Phosphorus and potassium were applied to all soils at the rate of 50 ppm before seeding the first, the third, and the fifth crop. The plants were harvested by cutting them at their stem bases, dried, and ground. Total nitrogen in the plants tissue was determined[2] and uptake of nitrogen by dry matter was computed. The correlations between total nitrogen uptake or dry matter weights with available nitrogen estimated by different methods were calculated.

## *Chemical methods*

1. Organic carbon of soils was determined by the Walkley and Black method[16]. 2. Total nitrogen contents of soil samples were determined by the Kjeldahl method[2]. 3. The hydrogen peroxide method for releasing inorganic nitrogen by oxidation of the soil organic matter was used for characterizing soil nitrogen availability. In this method 10 g ground soil samples were treated with 2 ml of 30% hydrogen peroxide solution in a conical flask of the presence of 20 ml of 2 *N* KCl, and this quantity of KCl was added to the soil samples to avoid fixation of the released $NH_4^+$-N by oxidation of organic matter. The reaction was allowed to proceed for about 15 minutes, with occasional swirling of the flask. The inorganic nitrogen released was then extracted by adding 80 ml of 2 *N* KCl and shaking the contents for hour. The soil suspension was filtered through a Whatman No. 40 filter paper and $NH_4^+$-N plus $NO_3^-$-N in the extract was determined by steam distillation with Devarda's alloy and MgO[3].

## *Incubation methods*

*Method 1*

Ten g soil samples in triplicate were incubated under flooded conditions with 20 ml water in 125 ml flasks (with their mouts covered with aluminium foil) at 30 °C for 2 weeks. After the incubation period, the $NH_4^+$-N released was extracted with 2 *N* KCl, and the $NH_4^+$ in the filtered extract was determined by steam distillation with MgO as described earlier.

*Method 2*

The method was essentially the same as described under method 1, with the only difference that after 2 weeks' incubation, the soil samples were analyzed for $NH_4^+$-N by direct distillation of the KCl soil suspension (instead of the filtered extract) with MgO[17].

## RESULTS AND DISCUSSION

As show in Table 1, the soils used in the study had a wide range in organic carbon (0.64 to 6.04%) and total nitrogen (0.07 to 0.35%) contents and evidently released varying amounts of $NH_4^+$-N during anaerobic incubation test (Table 4).

The $NH_4^+$-N released by treatment of the soil samples with hydrogen peroxide ranged from 88 to 343 ppm, indicating that this treatment released considerable amounts of ammonia (Table 4).

There were significant differences in the amounts of $NH_4^+$-N released in the incubation test under waterlogged conditions when determined by steam distillation of the extract or by distillation of the KCl-soil suspension with MgO after incubation. Direct distillation of KCl-soil suspension gave higher amounts of $NH_4^+$ as compared to the amounts of $NH_4^+$-N obtained with distillation of the extract, probably due to hydrolysis of soil organic matter with MgO[11].

However, the incubation test produced a wide range in the amounts of ammonium released during 2 weeks, which varied from 26 to 429 ppm with

Table 2. Dry matter yield from soils upon cropping six times (1–6) with IR 32 under flooded conditions

| | Dry matter wt (g/pot) | | | | | | |
|---|---|---|---|---|---|---|---|
| Soil | 1 | 2 | 3 | 4 | 5 | 6 | Total |
| Buenavista clay loam | 10 | 39 | 8 | 10 | 4 | 4 | 75 |
| Calalahan sandy loam | 0* | 0* | 3 | 36 | 12 | 17 | 68 |
| Paete clay loam | 1** | 62 | 26 | 36 | 16 | 12 | 153 |
| Luisiana clay | 5 | 9 | 27 | 22 | 8 | 7 | 78 |
| Maahas clay | 6 | 22 | 9 | 11 | 6 | 6 | 60 |
| Pila clay | 11 | 48 | 22 | 18 | 9 | 9 | 108 |
| Quingua silty loam | 6 | 25 | 11 | 13 | 7 | 6 | 68 |
| Lipa loam | 10 | 47 | 9 | 13 | 6 | 6 | 91 |

* No plant growth due to iron toxicity (Sahrawat[10]).
** Growth of plants retarded by production of reduction products in the soil.

Table 3. Nitrogen uptake from eight soils by six crops (1–6) of IR 32 under flooded conditions

| | N uptake (mgN/kg of soil) | | | | | | |
|---|---|---|---|---|---|---|---|
| Soil | 1 | 2 | 3 | 4 | 5 | 6 | Total |
| Buenavista clay loam | 34 | 59 | 10 | 15 | 5 | 5 | 128 |
| Calalahan sandy loam | 0* | 0* | 5 | 53 | 12 | 18 | 174 |
| Paete clay loam | 4** | 193 | 57 | 101 | 39 | 40 | 434 |
| Luisiana clay | 21 | 24 | 74 | 47 | 11 | 10 | 187 |
| Maahas clay | 19 | 19 | 10 | 14 | 8 | 9 | 79 |
| Pila clay | 34 | 109 | 44 | 39 | 13 | 13 | 252 |
| Quingua silty loam | 18 | 74 | 24 | 30 | 10 | 10 | 166 |
| Lipa loam | 31 | 103 | 17 | 20 | 14 | 9 | 194 |

* No plant growth due to iron toxicity (Sahrawat[10]).
** Growth affected by production of reduction products in the soil.

extract distillation and 30 to 485 ppm with KCl-soil suspension distillation, for the soils used (Table 4).

The correlation between dry matter or nitrogen uptake by six croppings of IR 32 rice and the available nitrogen determined by various methods indicated that the correlations were generally higher for N uptake than with the dry matter weights for the tests used for available nitrogen (Table 5). The data on dry matter weights and nitrogen uptake for the six cropping of IR 32 rice (Tables 2 and 3) provided a wide range in the amounts of nitrogen uptake and dry matter yield.

Table 4. Amounts of available N by different methods used

| Soil | Amount of available N (ppm) | | |
|---|---|---|---|
| | Incubation followed by | | |
| | KCl extract distillation | Direct soil-KCl distillation | N released by $H_2O_2$oxidation |
| Buenavista clay loam | 67 | 72 | 95 |
| Calalahan sandy loam | 66 | 76 | 205 |
| Paete clay loam | 429 | 485 | 343 |
| Luisiana clay | 68 | 74 | 107 |
| Pila clay | 94 | 113 | 145 |
| Maahas clay | 26 | 30 | 139 |
| Quingua silty loam | 71 | 78 | 88 |
| Lipa loam | 57 | 67 | 101 |

Table 5. Correlations between dry matter weight, N uptake, and available N values by different methods (n = 8)

| Parameter compared | Correlation coefficient (r) with | |
|---|---|---|
| | Dry matter yield | N uptake |
| 1. Organic carbon | 0.94** | 0.95** |
| 2. Total N | 0.93** | 0.93** |
| 3. Incubation (30°C, 2 weeks) followed by direct distillation of soil | 0.89** | 0.91** |
| 4. Incubation (30°C, 2 weeks) followed by distillation of KCl extract | 0.89** | 0.91** |
| 5. $H_2O_2$ method | 0.77 | 0.81* |

* Significant at the 5% level.
** Significant at the 1% level.

It is also clear that organic carbon or total nitrogen contents of soils and the amount of ammonia released under anaerobic incubation could be used for predicting the nitrogen-supplying capacity of soils used. However, nitrogen released by the oxidative action of hydrogen peroxide treatment gave comparatively poor correlation with dry matter weights or nitrogen uptake (Table 5).

There was no difference between KCl extract distillation and KCl-soil suspension distillation following incubation of the soil samples for 2 weeks as far as correlation with dry matter weight or nitrogen uptake was concerned. However, as noted earlier[11], direct distillation gave higher values for $NH_4^+$ over the KCl extracts for all soils.

Thus, in contrast to earlier reports by some researchers[4,5,13] the present study demonstrated that organic carbon content or total nitrogen content of soils are highly correlated with dry matter yields and nitrogen uptake. However, these observations are in agreement with the findings of others[1,9,14], who also reported that simple tests like determination of organic carbon and total nitrogen could be useful as routine tests for evaluating soil nitrogen availability. This study offers encouragement for further testing of organic carbon and total nitrogen contents of soil as indexes for soil nitrogen availability to rice with a large number of soils.

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