Relationships between soil urease activity and other properties of some tropical wetland rice soils

KL SAHRAWAT

The International Rice Research Institute, Los Banos, Laguna, Philippines*

Key words: active Fe and Mn, CEC, correlations, organic C, pH, total N

Abstract: Ten Philippine wetland rice soils differing widely in pH, texture and organic matter were studied to determine relationships between urease activity and other soil properties. Simple correlation analyses of urease activity with soil properties indicated that urease activity was correlated highly significantly with total N (r = 0.91)**, and organic C (r = 0.89**) but was not significantly correlated with CEC, Clay, pH active Fe or active Mn content. From multiple regression analyses it was observed that organic matter content of soils measured by organic C and total N accounted for most of the variation in urease activity.

Soil properties affecting urease activity have been studied in detail for upland soils [3] but there have been few studies of the urease activity in rice soils in relation to other soil properties though urea is the most commonly used N fertilizer on rice soils in the tropics [8]. Limited studies of urease in wetland rice soils have indicated that urea hydrolysis is affected by soil pH and is not affected by moisture content [7]. In another study Sahrawat [9] observed that urea hydrolysis followed a zero order kinetics in three Indian soils at least upto 12h of incubation, and the urease activity increased with the increase in organic C and total N contents of soils. Vlek et al. [11] reported that the urease activity in three flooded soils were not constant but were dynamic and changed with the duration of flooding. These results conflict with those reported by Zantua and Bremner [14], who reported that the urease activity in Iowa soils were quite stable and did not change even after waterlogged incubation of the soils for 6 months.

Studies by Dalal [5] and Zantua et al. [15] have shown that the urease activity in Trinidad and Iowa soils were highly significantly related to organic carbon, total N and cation exchange capacity of soils. In an earlier communication, I reported on the levels of urease activity in diverse Philippine wetland rice soils and their flood water. It was found that the acid sulfate soils had lower urease activity than organic soils and other mineral soils having near neutral or alkaline pH [10]. The aim of the work reported here was to

*Present address: International Crops Research Insitute for the Semi-Arid Tropics (ICRISAT), ICRISAT Patancheru P.O., Andhra Pradesh 502 324, India

Fertilizer Research 4: 145–150 (1983) 0167–1731/83/0042–0145/$01.20

examine the relationships between urease activity and other soil properties with 10 diverse Philippine wetland rice soils, having a broad range in pH, organic matter, texture, and other properties.

Materials and methods

The soils used (Table 1) were 10 surface (0–15 cm) samples collected from important rice growing areas of the Philippines. The soil samples were air-dried and crushed to pass through a 2-mm sieve before use in the study. Soils used had a wide range in pH (3.4 to 7.5), organic C (0.64 to 4.76%), total N (0.07 to 0.48%), CEC (6.5 to 41.5 m.e./100 g of soil), active iron (0.55 to 4.25%), active manganese (0.002 to 0.104%), and clay content (5 to 46%).

For soil analyses reported in Table 1, pH (1:1 soil to water) was measured by a glass electrode, organic C and total N were determined by the methods of Walkley and Black [12] and Bremner [2] respectively. CEC and particle size analyses were done as described by Chapman [4] and Day [6] respectively. Active iron and manganese (easily reducible) from soil samples were extracted by the method of Asami and Kumada [1].

The method used for the assay of urease activity in soils was the non-buffer method of Zantua and Bremner [13] with some modifications as described previously [10]. All analyses and experiments reported were done in duplicate. Relationships between soil urease activity and other soil properties were worked out using simple correlation and multiple regression analyses.

Results and discussion

The urease activity of the soils expressed as $\mu g\, NH_4^+$ formed per g of soil per hour at 30°C [10] ranged from 8.0 to 23.6 μg (Table 1). Simple correlation analyses showed that the soil urease was highly significantly correlated with total N($r = 0.91^{**}$) and organic C contents ($r = 0.89^{**}$), but was not significantly correlated with CEC, Clay, pH, active iron or active manganese contents of soils (Table 2). Simple correlations between urease activity and other soil properties with 9 soil samples after excluding Paete clay loam which was highest organic C (4.76%) and total N (0.48%) showed again that soil urease was significantly correlated with organic C($r = 0.71^{*}$) and total N ($r = 0.84^{**}$). Soil urease activity was not significantly correlated with other soil properties (Table 3). These results corroborate the findings of Dalal [5] and Zantua et al. [15], who reported that the urease activity was highly correlated with organic C and total N contents of soils. Additionally, studies by Dalal [5] indicated that the urease activity in 15 Trinidad soils was related to oxalate extractable Fe and Al, and CEC and clay content but was not significantly correlated to pH. Zantua et al. [15] found that

Table 1. Analyses of the soils used

Soil	pH	Organic C (%)	Total N (%)	Clay (%)	Active Fe (%)	Active Mn (%)	CEC (me per 100 g)	Urease activity*
Calalahan sandy loam	3.4	1.57	0.11	5	1.44	0.002	8.0	8.4
Malinao loamy sand	3.7	1.22	0.09	13	4.25	0.013	6.5	8.0
Luisiana clay	4.3	1.94	0.18	44	3.12	0.082	16.5	18.2
Paete clay loam	5.6	4.76	0.48	24	1.52	0.039	40.9	23.6
Buenavista clay loam	5.7	0.64	0.07	33	1.71	0.036	34.6	8.8
Bani clay	6.1	1.20	0.07	46	0.55	0.010	36.8	8.4
Maahas clay	6.3	1.50	0.13	46	1.55	0.104	38.5	12.0
Quingua silty loam	6.5	1.22	0.11	18	1.94	0.060	33.8	10.3
Pila clay	7.5	2.26	0.19	39	0.86	0.062	40.2	12.0
Lipa loam	7.5	2.50	0.19	23	0.72	0.028	41.5	15.6

* Urease activity expressed $\mu g\ NH_4^+ - N$ formed per g of soil per hour at 30 °C [10].

Table 2. Correlations between soil urease activity and other soil properties (n = 10)

Soil property	Correlation coefficient (r)
Total N	0.91**
Organic C	0.89**
Active Mn	0.39 ns
CEC	0.33 ns
pH	0.15 ns
Clay	0.10 ns
Active Fe	− 0.5 ns

** = Significant at 1% level
ns = Not significant

Table 3. Correlations between soil urease activity and other soil properties with nine soils after excluding Paete clay loam (Organic C 4.76, total N 0.48%)

Soil property	Correlation coefficient (r)
Total N	0.84**
Organic C	0.71*
Active Mn	0.57 ns
Clay	0.38 ns
pH	0.25 ns
CEC	0.19 ns
Active Fe	0.009 ns

** = Significant at 1% level
* = Significant at 5% level
ns = Not significant

urease activity in 21 Iowa soils was correlated very highly with organic C, total N, and CEC but was not significantly correlated with pH. The results of this study showed that the urease activity was not related to soil pH and was mainly controlled by organic matter content as measured by organic C and total N contents of soils. Dalal [5] also reported that the soil urease in the absence of toluene was associated with the organic matter of soils. The method used in the present study was a non-buffer and also did not involve the use of toluene and thus supports the conclusion drawn by Dalal [5].

Stepwise multiple regression analysis showed that organic C accounted for 79.2% of the variability in urease activity. Total N alone accounted for 82.7% of the variance in urease activity by the following regression equation:

$$\text{Urease activity} = 6.3 + 38.7\,(\text{Total N}) \quad (1)$$

Though active Mn was not significantly correlated with urease activity (Table 2) its combination with total N accounted for 87.6% of the variation in soil urease activity by the following regression equation:

$$\text{Urease activity} = 4.9 + 37.4\,(\text{Total N}) + 34.8\,(\text{Active Mn}) \quad (2)$$

$$R^2 = 87.6\%$$

The regression of urease activity with soil properties which accounted for the most variability ($R^2 = 89.6\%$) in urease by the following equation.
Urease activity = 4.0 + 25.0 (Total N) + 29.4 (Active Mn)-0.06 (Clay)

$$- 0.05 \text{ (CEC)} + 1.6 \text{ (Org. C)} \qquad (3)$$

which has only marginally better prediction of urease activity than done by equation (2). Multiple regression analyses further indicated that the other soil properties did not significantly contribute to the variance in urease activity in the soils. It can be inferred from these results based on simple correlations and multiple regression analyses that organic matter measured by organic C and total N content accounted for most of the variance in soil urease. These results are in agreement with those of Zantua et al. [15], who found that organic matter accounted for most of the variance in urease in Iowa soils.

Acknowledgements

I thank the International Rice Research Institute (IRRI), Los Banos, Philippines for financial support, and Dr. F.N. Ponnamperuma, Principal Soil Chemist, IRRI for facilities and interest in the work.

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