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UREASE ACTIVITY IN RICE SOILS AS INFLUENCED BY MOISTURE REGIMES AND RICE RHIZOSPHERE

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Abstract: Urease activity in six rice soils of Kerala namely laterite (Oxisol), karappadam (Inceptisol), kari (Inceptisol), kole (Inceptisol) and black soil (Vertisol) were studied at 60% WHC and under submergence. The pattern of urea hydrolysis was same at 60% WHC and under submergence. While the black soil exhibited the highest urease activity, kari soil registered the lowest activity. When soils were incubated for periods longer than 5 h (at both the moisture regimes) the urea hydrolysis was complete within two days in laterite, karappadam and kayal soils. For black and kole soils it took five days and for kari soil 30 days for the completion of urea hydrolysis. The rice rhizosphere was found to have a positive influence on urease activity and the maximum urease activity in the rhizosphere was noticed at 60lh day after planting.

INTRODUCTION

Urease (urea amidohydrolase, EC 3.5.1.5) catalyses the hydrolysis of urea to carbondioxide and ammonia. Urease is unique among soil enzymes as it generally affects the fate and performance of applied urea. In the soil, urea is hydrolysed enzymatically by urease to ammonium and carbondioxide. A rapid hydrolysis of urea is likely to result in serious volatilization loss of ammonia in light soils with high pH. On the other hand, a slow rate of hydrolysis is likely to increase the leaching loss of urea. Hence, proper evaluation of the urea hydrolysing power of any soil is essential to improve the nitrogen use efficiency. Urease activity is known to vary widely in different soils (Mc Garity and Myers, 1967) and it is influenced by several factors such as pH, organic matter, soil submergence, rhizosphere etc. (Kumar and Wagnet, 1984; Savant *et al.*, 1985). In this paper the urease activity of six rice soils of Kerala is studied as influenced by soil submergence and rice rhizosphere.

MATERIALS AND METHODS

Six major types of rice soils of Kerala namely laterite (Oxisol), karappadam (Inceptisol), kari (Inceptisol), kayal (Inceptisol), kole (Inceptisol) and black soil (Vertisol) were used for the study. Surface samples (0-15 cm depth) representing these soils were air-dried and ground to pass through a 2 mm sieve prior to use in the studies. The physico-chemical properties of the soils are given in Table 1.

Urease activity of the soils was studied at 60% WHC and under submergence. Five gram portions of each soil were treated with urea (2 mg/g soil) and incubated for different intervals namely, 2, 5, 10, 15, 20, 24, 48, 120, 240, 480 and 720 h. In the first case (60% WHC) incubation was performed in plastic bottles (200 ml) after the water content of the soil was adjusted to 60% WHC. In the second case, incubation was performed in glass tubes (30 x 120 mm, 30 ml capacity) after submerging the urea-teated soil with 5 ml of distilled water. Sufficient number of replications for each soil were kept to allow the removal of duplicate tubes at each interval for the determination of urease activity, by the non-buffer method of Zantua and Bremner (1975).

To examine the role of rice rhizosphere, a pot culture experiment using the six soils was conducted during the period from January to May 1989 using the rice variety Jyothi. Plastic pots of capacity 4 1 were filled with 2 kg of each soil and two rice seedlings (20 days old) were planted in each pot and grown under flooded condition. There were three replications for each soil. Three pots containing soil but without growing rice were also kept for each soil type. Nitrogen was applied (@ 75 kg/ha) as ammonium sulphate, phosphorus (@ 35 kg/ha) as superphosphate and potassium (@ 35 kg/ha) as muriate of potash. Urease activity of different soils, with and without growing rice, was estimated by drawing soil samples from the rhizosphere at the time of planting, 30 days after planting PAP), 60 DAP and at harvest by the non-buffer method (Zantua and Bremner, 1975). The study could not be completed, however, with kari soil as the rice seedlings wilted due to acute acidity a few days after planting.

RESULTS AND DISCUSSION

Urea hydrolysis at different moisture regimes

There was marked variation in urease activity of the different soil types at 60% WHC (Table 2). While the black soil exhibited the highest urease activity (for 5 h incubation) the kari soil registered the lowest activity. The urease activities of other soils did not show much variation after 5 h incubation period and the values ranged from 250 to 285 μg urea hydrolysed per gram of soil. Many studies have related soil urease activity with soil properties like organic carbon, total N, pH, CEC and sand, silt and clay content (Mc Garity and Myers, 1967; Zantua *et al.,D 1977; Dash et* «/. 1981). While some workers reported a positive relation, some did not get any relationship at all. In the present study, though kari soil which gave the lowest activity was having fairly high organic carbon content it was low in silt and clay content (Table 1). The pH of this soil was as low as 2.5 even after submergence for a long period. The low pH of the soil could be one of the main reasons for the low activity as the optimum pH for urease activity is in the range of 6 to 9 (Tabatabai and Bremner, 1972; May and Douglas, 1976). The black soil which showed the highest activity was having a higher pH of around 8 and CEC of 52.4 me/100 g soil. The cation exchange sites in soil are believed to retain urease as is evident from the significant positive correlation between urease activity and CEC (Dalai, 1975; Zantua *et al.,* 1977). Laterite, karappadam, kayal and kole soils which had a slightly lower level of activity were having a pH of around 4.7 and CEC ranging from 4 to 20 me/100 g soil.

The pattern of urea hydrolysis of the soil when submerged for 5 h interval was almost the same as that at 60% WHC (Table 2). In this case soil was kept submerged only after the addition of urea. Hence at the time of incubation with urea the soil was aerobic. Several workers have also found that urease activity in soil was not affected by the water level (Skujins and Mc Laren, 1969; Gould *et al,* 1973).

Remarkable difference in urea hydrolysis of the soil types was exhibited when it was incubated for intervals longer than 5 h (both at 60% WHC and under submergence). The urea hydrolysis was complete within two days in the case of laterite, karappadam and kayal soil. For black and kole soils, it took five days and for kari soil it took 30 days for the completion of urea hydrolysis (Table 2). The very slow rate of hydrolysis of urea in kari soil should be expected as the soil is strongly acidic (pH 2.5) and acidity is known to inhibit urea hydrolysis (Bremner

Table 1. Physicochemical properties of the soils

Characteristic	Soil type					
	Laterite	Karappad	[illegible]	Kayal	Kole	Black
pH (1:2.[illegible]	4.7	4.6	2.5	4.4	4.7	8.0
Organic carbon, %	0.38	1.62	3.96	1.	1.5	0.6[illegible]
Total N, %	0.1	[illegible]8	0.25	[illegible]	[illegible].26	[illegible]3
Available P, ppm (Bray 1)	19.0	4.5	5.0	.5	2.5	7.25
Available K, ppm (NH$_4$OAc - pH 7)	70.0	1[illegible].0	25 0	140.0	140[illegible]	350.[illegible]
CEC, [illegible] soil	3.8	12.7	[illegible]3	16.4	[illegible]	52.4
Maximum [illegible]	34.0	56.1	59.4	74.	[illegible]7.	72.8[illegible]
Field capacity, %	11.7	22.1	25.7	37.8	31.3	35.1
Sand, %	85.0	60.0	66.3	75.0	55.0	73.8
Silt, %	12.5	31.3	26.2	8.7	23.7	10.0
Clay, %	2.5	8.7	7.5	16.3	21.3	16.2

Table [illegible]. Level of urease activity in the six soil types at 60% WHC and under submergence for different incubation periods

Incubation period (h)	Urease activity (µg urea hydrolysed per g soil)											
	Laterite		[illegible]ppadam		Ka[illegible]		[illegible]al		Kole		Black	
	60% WHC	Submergence	60% WHC	Submergence	60% WHC	Submergence	60% WHC	Submergence	60% WHC	Submergence	60% WHC	Submergence
2	0	0	0	0	0	0	29	0	11	0	66	0
5	248	212	285	248	175	139	230	175	[illegible]	175	321	212
10	613	759	686	978	212	248	759	1197	[illegible]	431	905	431
15	1544	1069	1526	1142	248	139	1763	1489	832	449	1015	540
20	1872	1788	1745	1531	248	66	1836	1785	942	686	1343	942
24	1939	1796	1919	16798	285	175	1925	1905	1170	1124	1124	[illegible]
48	1971	1920	1993	1927	467	175	1989	1920	1932	1905	1558	[illegible]
120	2000	2000	2000	2000	850	467	2000	2000	1954	2000	1945	[illegible]
240	2000	2000	2000	2000	668	686	2000	2000	2000	2000	2000	[illegible]
480	2000	2000	2000	2000	1967	1971	2000	2000	2000	2000	2000	[illegible]
720	2000	2000	2000	2000	1967	1971	2000	2000	2000	2000	2000	2000

Note: The quantity of urea added is 2000 µg/g soil

Table 3. Effect of rhizosphere on urease activity of soils at different stages of rice growth

Soil type	Urease activity (µg urea hydrolysed/g soil/5h)							
	At the time of planting		30 DAP		60 DAP		At harvest	
	Without rice	With rice	Without rice	With rice	Without rice	With rice	Without rice	With rice
Laterite	175	139	90	248	175	394	139	285
Karappadam	226	153	175	273	200	321	187	309
Kayal	226	153	224	309	236	467	224	321
Kole	54	66	151	273	236	423	212	321
Black	200	248	273	394	248	492	285	394

Table 4. Results of paired 't' test on soil urease activity in the rice rhizosphere at 30 DAP, 60 DAP and at harvest

Comparisons	't' value	
	Calculated	Table
With and without growing rice at 30DAP	5.62*	2.12
With and without growing rice at 60 DAP	9.11*	2.15
With and without growing rice at harvest	9.4*	2.15
30 DAP and 60 DAP	2.75*	2.15
60 DAP and at harvest	5.41*	2.15
30 DAP and at harvest	0.0025	2.15

* Significant at 5% level

and Mulvaney, 1978). Sahrawat (1980) also observed that acid sulphate soils had a lower urease activity than soils with near neutral or alkaline pH.

Influence of rice rhizosphere on urease activity

The comparison by paired t-test between urease activities of soils with and without growing rice at each of the three stages of growth, 30 DAP, 60 DAP and at harvest, shows a higher activity in soils in which rice was grown (Table 3). Urease activity in the rice rhizosphere was found to increase with the growth of rice plants up to 60 days and thereafter it declined. From the comparison of urease activities between the three stages of crop growth by paired t-test it was seen that urease activity in the rhizosphere was highest at 60th day after planting (Table 4). Urease activities in the rice rhizosphere at 30th day after planting and at harvest were at par.

The higher activity of urease in cropped soil may be due to the microbial activity in the rhizosphere. The activity of soil enzymes has been reported to be correlated with the microbial activity (Frankenberger and Dick, 1983; Tiwari *et al.*,1988). The results also showed that maximum activity was on 60th day after planting. This may be due to the highest root activity at this stage. Extracellular urease had been reported to be associated with rice roots (Mahapatra *et al.*, 1977). In addition, rice rhizosphere is relatively oxidised because of diffusion of O_2 from the rice roots (Armstrong, 1971). The presence of rice roots in the wetland soil system is thus likely to influence the urea hydrolysis.

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