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Influence of Some Soil Properties and Temperature on Urease Activity in Wetland Rice Soils

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Abstract: Soil enzymatic activities are the biological indices reflecting soil fertility and quality. In order to evaluate the influence of some physical and chemical characteristics wetland rice soils and temperature on urease activity, a lab experiment was carried out in Rice Research Institute of Iran. Thirty soil samples were selected from different wetland rice soils of Guilan province in north of Iran. Urease activities range from 17.5 to 66.3 and 11.2 to 45 µgNH_4^+/g soil/2hr at 24° and 16°C, respectively. A significant negative correlation (r = -0.62** at 24°C and -0.58** at 16°C) was observed between urease activity and soil pH reaction by quadratic regression equations. Relation of organic carbon with urease activity was generally quadratic correlated highly significantly with urease activity, with r values of 0.84***and 0.77*** at 24°C and 16°C, respectively. While soil total N and Clay content were best described by linear regression equations. Some of r values weakened progressively with decrease in temperature.

Key word: Fertilizer · Nitrogen · Rice · Urease activity · Wetland

INTRODUCTION

The demand for rice continuse to increase owing to continued growth of population. It is predicted that a 50 to 60% increase in rice production will be required to meet demand from population growth by 2025 [1]. Nitrogen supply commonly limits grain yield in irrigated rice systems. The demand of the rice plant for other macronutrients depends mainly on the N supply [2]. Urea is one of the most important chemical N fertilizers and its application has been recently increased in Middle East because of its low cost, ease in handlig and high nitrogen content [3]. Urea hydrolysis in soils is an enzymatic decomposition process by the enzyme urease. Information on the nature of ureas activity of a soil and changes in the urea hydrolysis is beneficial to develop and employ strategies for efficient N management. The use of enzyme activity measurements as indicators of soil functionality and thus as indicators of soil quality and activity of the microbes, has been extensively discussed [4, 5]. Urease (urea amidohydrolas; EC 3.5, 1:5) catalyzes the hydrolysis of urea to yield ammonia and carbamate, which spontaneously hydrolyzes to form carbonic acide and a secound molecule of ammonia [6].

$$H_2N-\overset{\overset{\large O}{\|}}{C}-NH_2+H_2O\xrightarrow{\text{urease}}NH_3+H_2N-\overset{\overset{\large O}{\|}}{C}-OH$$

$$H_2N-\overset{\overset{\large O}{\|}}{C}-OH+H_2O\longrightarrow NH_3+H_2CO_3$$

Soil urease (urea amidohydrolase) is involved in nitrogen mineralization and supplying nitrogen to plants from natural and fertilizer sources. The rate of urea hydrolysis depends on several factors such as soil type, organic matter content (OM), soil moisture content, $CaCO_3$ content, temperature, level of salinity and alkalinity. Some of these factors accelerate and others retard the rate of urea hydrolysis in soils [7]. Reports of the influences of some of soil properties on soil urease activities are inconsistent [8]. Nourbakhsh and Monreal [9] reported that significant negative correlation between urease activity and electrical conductivity (EC) of saturation paste extracts in calcareous soils. There have been few studies of the urease activity in wetland rice soils in relation to other soil properties though urea is the most commonly used N fertilizer on rice soils of Iran. The present study was conducted to evaluate the effects of some of soil properties and temperature on urease activity in wetland rice soils under laboratory conditions.

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MATERIALS AND METHODS

The soil samples, which were used in investigation, were collected from different parts of the wetland rice soils of Guilan province in north of Iran. With this aim the soil samples were taken 0-30 cm depth and 30 soil samples were used in research represent all soils of Guilan province (36°36' to 38°37' N and 48°25' to 50°34' E). The samples were air dried ground and passed through a 2 mm sieve and kept in sealed glass containers. Urea was applied in 100 kg N ha^{-1} as solution in these soils. Soil samples were subjected to 14 days incubation at 24 and 16°C. Selected soil physical and chemical properties were determined by means of appropriate methods: soil particle size distribution by the hydrometer method, pH in saturation paste by pH-meter, electrical conductivity of soil saturation extracts (ECe) with Metrohm conductometer by Jackson [10]. Organic carbon (OC) was determined following the wet digestion method as described by Walkley and Black [11]. Total nitrogen (TN) was determined by the Kjeldahl procedure as described by Jackson [10]. Cation exchange capacity (CEC) by Bower method [12]. Urease activity was measured in 0.05 M Tris hydroxymethyl aminomethane (THAM) buffer pH = 9.00 in soils according to the method of Tabatabai and Bremner [13]. Simple linear and stepwise regression analyses were used for describing the relationships between ureas activity and soil physical and chemical properties.

RESULTS AND DISCUSSION

Some descriptive statistical results of selected soil physical and chemical properties are given in Table 1. Soil properties varied widely with respect to soil particle size distribution, OC, TN, CEC, ECe and Clay content. Ureas activities in two temperatures in different rice soils are given in Fig. 1. Under studied soil in this expriment, urease activity is excessive in high temperature. Similar results were reported by Cartes, *et al*. [14] in Chileian soils and O' Tool, *et al*. [8] in Irish soils. Whereas urease enzyme is a factor analysis urea, so for prevention of ureae losing, so do not use it in high temperatures in rice soils it is recomended. Simple linear correlation coefficients between urease and soil physico-chemical properties are shown in Table 2. Urease activity showed significant positive liner correlation with TN (0.82** and 0.74**), clay content (0.44* and 0.47**) and quadratic correlation

Table 1: Descriptive statistics for selected properties of wetland rice soils (n=30)

Soil properties	Unit	Mean	Min.	Max.	C.V
Clay	%	31.2	18	40	19
Silt	%	37.5	18	55	26
Sand	%	31.3	16	53	37
Electrical conductivity	dS m^{-1}	1.54	0.57	3.98	58
pH	-	7.1	5.6	7.9	9.2
Organic carbon	%	2.15	0.66	5.37	58
Total nitrogen	%	0.23	0.06	0.55	59
C/N	-	9.7	6.2	16.4	23
Cation exchange capacity	Cmol kg^{-1}	33	17	52	26
Urease activity (UAc), 16°C	μ g NH_4^+/g soil/2hr	27	11.2	45	-
Urease activity (UAc), 24°C	μ g NH_4^+/g soil/2hr	38.5	17.5	66.3	-

C.V: Coefficient of variation

Table 2: Simple linear correlation coefficients (*r*) of urease activity and soil properties

Temp.	Soil properties	Correlation coefficients	Equations
24°C	Clay (C)	0.44*	Y= 0.7063 Clay + 17.099
	Silt (Si)	0.08 ns	Y= -0.0972 Silt + 42.185
	Sand (S)	0.19 ns	Y= -0.1832 Sand + 44.386
	Total nitrogen (TN)	0.82**	Y= 66.04 N + 23.501
	Cation exchange capacity (CEC)	0.30 ns	Y= 0.3704 CEC + 26.202
	C/N	0.36 ns	Y= 1.3649 C/N + 24.615
16°C	Clay (C)	0.47**	Y= 0.5595 Clay + 10.07
	Silt (Si)	0.13 ns	Y= -0.1017 Silt + 31.258
	Sand (S)	0.18 ns	Y= -0.1264 Sand + 31.269
	Total nitrogen (TN)	0.74**	Y= 43.48 N + 17.333
	Cation exchange capacity (CEC)	0.35 ns	Y= 0.3244 CEC + 16.432
	C/N	0.30 ns	Y= 0.821 C/N + 18.857

UA; urease activity * and ** are significant at 0.05, 0.01 respectively

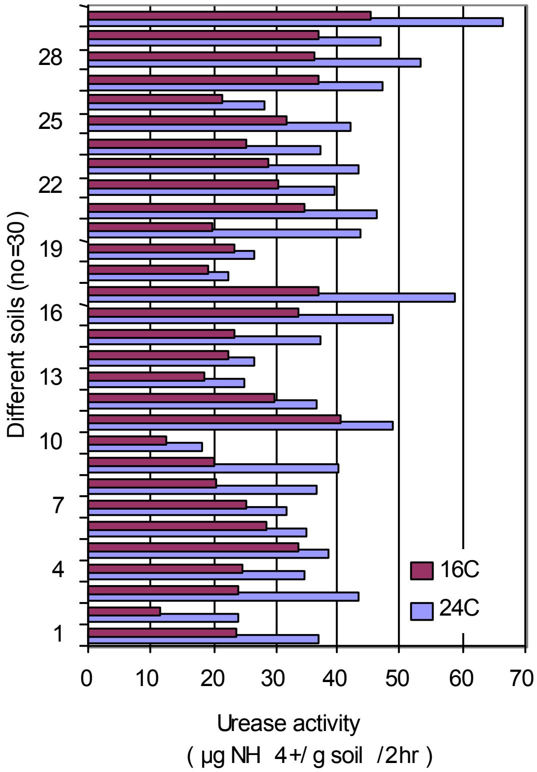

Fig. 1: Urease activity in different paddy soils at two temperatures

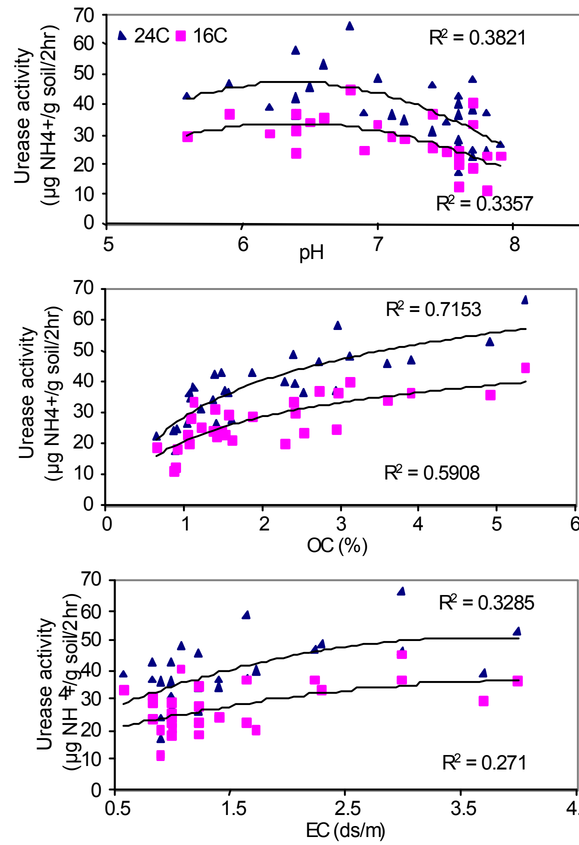

Fig. 2: Relation of Urease activity with some of rice soil properties

with OC (0.84*** and 0.77***) at 24 and 16°C, respectively (Fig. 2). Studies by Dalal [15] and Zantua *et al*. [16] have shown that the urease activity in Trinidad and Iowa soils were highly significantly related to OC, TN and CEC of soils too. Close association between organic matter content of soil and urease activity has been demonstrated in many investigations [9, 17, 18]. Urease is produced by soil micro-organisms and released in to the soil for its action. Pattnaik *et al*. [19] reported that 79 to 80 % urease activity was extracellular and complexed by soil colloids. Such a positive relationship between urease activities and soil OC content might be due to a higher level of microbial biomass and greater stabilization of extracellular urease by humic molecules [20]. The significant correlation between urease activities and soil total N content may be an indirect consequence of significant correlation between soil OC and TN [21]. Mohammadi [22] explained that urease is released from living and disintegrated microbial cells and in the soil it can exist as an extra cellular enzyme absorbed on clay particles or encapsulated in humic complexes.

Urease activity showed quadratic correlation with soil pH (0.62** and 0.58**) and EC (0.57** and 0.52*) at 24 and 16°C, respectively (Fig. 2). Results show that urease activity increased slowly, reached a maximum within pH= 6 to 7 and then decreased rapidly to 8. Under experiment conditions, maximum urease activities is within EC= 0.5 - 1.5 dSm^{-1} and than EC increase no problem in urease activities. Differnt results were reported on uease activity, EC and pH [14, 3, 9]. There were no significant relationships between urease activity and CEC, silt, sand and C/N. Similar results were reported by Nourbakhsh [9] and Baligar [23] for CEC and soil texture. Stepwise multiple regression analysis showed that TN in paddy soils studied contributed significantly to explaining 69 and 61 % of the variation in urease activity in 24 and 16 °C, respectively. Apparently urease activity of these paddy soils studied was mostly controlled by TN that is linked with OC (Fig. 2).

CONCLUSION

Obtained results in this study have shown a positive significant liner correlation between urease activity with TN, Clay content and quadratic correlation with OC, pH and EC. Urease activity is mostly controlled by TN that is linked with OC. In the soils studied urease activity is increased in high temperature. Evidently salinity condition in humid to semi humid soils have no restricted effects on urease activity.

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