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Redox Potential in the Rhizosphere Soil of Rice Hybrid as Mediated by Crop Management Options

C. Sudhalakhsmi, V. Velu and T.M. Thiyagarajan

Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore – 641 003, Tamil Nadu, India.

Abstract: The oxidation – reduction (Eh) system is a chemical reaction in which electrons are transferred from a donor to an acceptor which is an important index for characterizing the degree of oxidation or reduction of soil and reflects the equilibrium position between various redox systems. An experiment was conducted at the wetlands of Tamil Nadu Agricultural University, Coimbatore (11°N and 77° E) during dry season (Mar - June) 2002 in Noyyal series (Vertic ustochrept) to study the influence of altered crop management options viz., direct seeding, limited irrigation, conoweeding and green manuring practices over conventional planting, irrigation, weeding and nutritional methods on the redox potential in the rice rhizosphere region of rice hybrid ADTRH 1. The redox potential was measured using platinum electrode. The results revealed that direct seeding, limited irrigation and conoweeding practices have resulted in substantial increase in the redox potential while green manuring has considerably reduced the redox potential of the rhizosphere region.

Key words: *Redox potential, rice hybrid, direct seeding, conoweeding, limited irrigation*

INTRODUCTION

Rice is the staple food of more than half the people in the world and is generally grown under submerged conditions. The oxidizing power of the roots protects the plants against reducing substances like ferrous iron or hydrogen sulfide, which may reach phytotoxic concentrations in waterlogged soils[11, 12]. Plants with larger rhizospheres will be significantly better protected from absorbing large amounts of reduced products and the oxygenation of small lateral roots is higher than the primary roots [2]. The higher oxidizing activity of rice roots is said to correlate with its resistance to Akiochi disease and the low activity with its susceptibility [1].

Crop management options like planting methods, weed management practices, irrigation and nutritional options have significant impact on the redox potential of the rhizosphere soil. Repeated use of rotating hoe with its wheels that aerate the top horizon of the soil leads to better development of the rice ecosystem through the possibility of rice roots' extended growth under the influence of oxygen[8]. The changes in Eh are more pronounced when organic substances are added to soils low in organic matter[3]. With this background the experiment was designed to bring out the influence of cultural practices on redox potential in the rhizosphere region of rice hybrid ADTRH 1.

MATERIALS AND METHODS

To explore the oxidizing power of rice roots as mediated by crop management options, an attempt was made in the universal crop " rice" at the wetlands of Tamil Nadu Agricultural University, Coimbatore during the dry season (Mar - June) 2002. The experiment was laid out in strip plot design with sixteen treatment combinations replicated four times. The extended short duration rice hybrid ADTRH 1 (105 d duration) was the test crop. The soil of the experimental site was clay loam classified taxonomically as Vertic ustochrept with pH: 8.3, electrical conductivity: 0.59 dSm^{-1}, organic carbon: 6.6 g kg^{-1}, Available N, P, K status: 190, 30 and 730 kg ha^{-1} respectively.

The crop management options (treatments) were

Planting Methods: (P)

P_1: Transplanting 24 days old conventional nursery seedlings at 20 x 20 cm spacing

P_2: Direct seeding during dry season

Irrigation (I):

I_1: Irrigating the field to 5 cm one day after the disappearance of ponded water

I_2: Irrigating the field to 2 cm after the development of hairline cracks

Corresponding Author: C. Sudhalakhsmi, Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore – 641 003, Tamil Nadu, India.

Weeding (W):

W_1: Manual hand weeding twice as per the farmers' practice (weeds removed)
W_2: Weeding by conoweeder at 10 days interval upto maximum vegetative period (weeds buried)

Green manure (N):

N_1: Recommended level of N, P, K and Zn without the addition of green manures
N_2: Recommended level of N, P, K and Zn with the addition of green manures @ 6.25 t ha^{-1}.

The redox potential of the rhizosphere soil was measured insitu using a portable pH meter with a platinum electrode calibrated to a redox value of +264.3 mV using pH 4.0[5]. The platinum electrode was inserted in the rhizosphere region at about 13 cm from the surface and the readings were noted. The redox potential was determined at the flowering stage during dry season.

RESULTS AND DISCUSSIONS

The redox potential of the soil as observed at the flowering stage of ADTRH 1 rice hybrid showed a wide variation among the treatments with the values ranging from + 77.2 to – 149.0 mV (Table 1 and Fig. 1). Though the variations in the Eh values under different management options failed to attain statistical significance, the favourable impact of the modified planting (direct seeding), limited irrigation as well as the conoweeding practice in registering an increase in the Eh values over the respective conventional methods was clearly evident. As a natural corollary, the impact of the green manure in favouring the reduction process in the soil has also been clearly brought out.

Measurement of redox with spatial resolution showed that rice roots could increase the redox potential in a reduced soil[10]. Early accumulation of vegetative biomass, higher leaf area, enforced total and productive tillers per unit area with profuse root system are considered to be the favourable characteristics of direct seeded flooded rice[7].

Table 1: Soil redox potential (mV) of rice hybrid ADTRH 1 as influenced by planting, weeding, irrigation and nutritional methods.

		Conventional planting (P_1)		Dry Seeding (P_2)			
		Conventional irrigation (I_1)	Water saving irrigation (I_2)	Conventional irrigation (I_1)	Water saving irrigation (I_2)	Mean	Mean
Weeds removed (W_1)	Recommended nutrients (N_1)	-137.9	-147.6	-74.7	-48.1	-102.1	
	N_1 + green manures (N_2)	-144.6	-140	-139.5	-112.5	-134.2	-118.2
Weeds incorporated (W_2)	Recommended nutrients (N_1)	-120	-134	-113	77.2	-72.5	
	N_1 + green manures (N_2)	-116.3	-149	-118	-101.8	-121.3	-96.9
Mean		-129.7	-142.6	-111.3	-46.3		
Mean		-136.2		-78.8		-107.6	
Mean		I_1 = -120.5;	I_2 = -94.5	N_1 = -87.3;	N_2 = -127.8		

(Standard value : +264.3 mV. CD (5%) is non – significant for all main factor effects and all possible interaction effects)

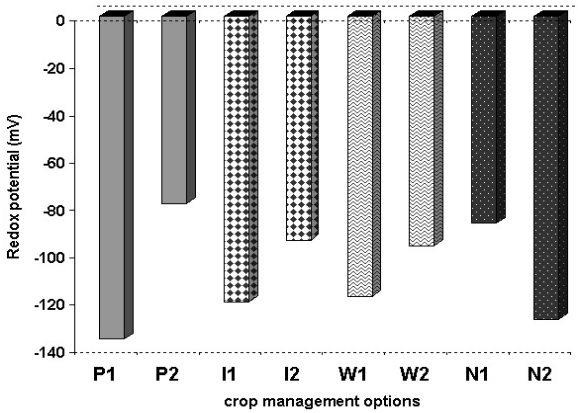

Fig. 1: Redox potential (mV) in the rhizosphere region of the rice hybrid ADTRH 1

Plants with larger rhizosphere region will be significantly better protected from absorbing large amounts of reduced products and the oxygenation of small lateral roots is higher than the primary roots as opined by Armstrong[2]. Thus in the present study, relatively higher redox potential observed under direct seeding is in close compliance with the above finding.

Drained field conditions enhanced the root oxidizing power and reduced the fraction of dark coloured roots[9]. In corroboration with the above fact, the redox potential under limited irrigation was higher than its alternative.

Aeration of top horizon of the soil with repeated use of rotating hoe was well documented[8]. Rotating hoe churns up the surface soil to remove weeds providing additional aeration which may contribute to greater biological nitrogen fixation by mixing aerobic and anaerobic soil horizons[6]. The redox potential recorded under conoweeding practice in the present study portrays the fact that the mechanical weeder can contribute to aeration of the soil by churning effect. Conoweeding practice for direct seeded crop in the absence of green manures has resulted in considerable increase in the redox status of the soil.

Green manure is a bioresource for sustainable agriculture. The relatively lower redox potential under green manuring practice would have attributed to the accumulation of organic metabolites including volatile fatty acids as acetic and hydric acids[13] and non-volatile fatty acids, tartaric acid, phenolic acids like p- hydroxybenzoic, vanillic and ferulic acids, aldehydes, alcohols and amines[4] resulting in reduced conditions in the soil system. The current research reveals that direct seeding, limited irrigation and conoweeding practices can contribute to aeration of the soil under submerged ecosystem resulting in oxidation of the rhizosphere region and to protect the roots from accumulation of toxic metabolites.

Conclusion: The results revealed that direct seeding, limited irrigation and conoweeding practices have resulted in substantial increase in the redox potential while green manuring has considerably reduced the redox potential of the rhizosphere region.

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