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RESEARCH PAPER

Relationship between Dehydrogense Activity and Physico-chemical Properties in Oil Palm Growing Soils of Andhra Pradesh

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ABSTRACT

Two adult oil palm plantations grown under irrigated conditions in Andhra Pradesh were taken up for studying the relationship between dehydrogenase activity and physico-chemical properties of soil. Soil samples were collected at different distances from palm (1 to 5 m) and depths (0-15, 15-30, 30-60 cm) by using standard triangular method. Standard methods were used for analyzing dehydrogenase activity and physico-chemical properties. The pH of the soils at different depths ranged from 6.72 - 7.53 and increased as the soil depth increased, while electrical conductivity ranged from 0.08 - 0.17 dS m^{-1} and decreased as the soil depth increased. Maximum dehydrogenase activity of 20.37 µg TPF g^{-1} day^{-1} was observed at 0-15 cm depth and decreased as soil depth increased. The organic carbon, available phosphorus and potassium contents in the soil decreased with soil depth. The findings indicate that dehydrogenase activity can be used as a measure of overall microbial activity for evaluating soil health in oil palm growing soils of Andhra Pradesh.

KEY WORDS : Dehydrogenase activity, oil palm, organic carbon.

INTRODUCTION

Oil palm is basically a humid tropical crop native to the Guinea Coast of West Africa. It is the highest edible oil yielding crop giving up to 3-6 tonnes of oil per hectare per year. Presently, oil palm is being cultivated in an area of 2.10 lakh ha in India. Scientific technologies and sincere attempts are being made towards the sustainable production of oil palm in coastal Andhra Pradesh.

Soil is the most valuable natural resource and maintenance of its health is a moral responsibility. Deep, well drained medium loam soil, rich in humus is suitable for oil palm cultivation. Soil organic matter quality and quantity is of much importance for soil water retention, sorption, buffering potential, etc. A number of soil microbiological parameters like microbial biomass, basal respiration and enzyme activity have been suggested as possible indicators for evaluating soil environmental quality in National and International monitoring programmes (Sparling, 1997; Trasar-Cepeda *et al.*, 2000; Yao *et al.,* 2003). Soil enzymes play a vital role in the catalysis of microbial reactions essential for decomposition and formation of organic matter, and are responsible for nutrient cycling and decomposition of organic wastes (Dick and Tabatabai, 1993). Total soil enzymatic activity is composed of both intracellular and extracellular enzymes. The dehydrogenase group of enzymes is the best example of exclusively intracellular enzymes. Dehydrogenases play a significant role in the biological oxidation of soil organic matter by transfering the proton from substrates to acceptors (Rossel *et al.*, 1997). The optimum pH range for dehydrogenase activity is between 7.4 - 8.5 and is considered to be the best predictor of dehydrogenase in the soil environment (Nagatsuka and Furosaka, 1980; Quichano and Maranon, 2002; Moeskops *et al.*, 2010). Hence, their activity is considered an indicator of the oxidative metabolism in soil and thus of microbial activity (Quilchano and Maranón, 2002).

As research on the role of microbial activity in the oil palm growing soils is very scarce under Indian conditions, the present study was taken up to understand the relationship between dehydrogenase activity and physico-chemical properties.

MATERIALS AND METHODS

The study was conducted in ten year old adult oil palm plantations located nearer to Pedavegi, West Godavari District, Andhra Pradesh. Pedavegi is situated at 16.8 N, 81.11 E, 13.41 m above mean sea level. The mean temperature ranged from a minimum of 24^0C to a maximum of 34^0C with an average rainfall of 648 mm during sampling period. The palms were planted in a 9 m triangular spacing and standard agronomical practices were followed.

Soil sampling was done by triangular sampling method as per Tailliez (1971) by using an auger (Chan, 1976). The triangle was sub divided into 16 sub triangles with sides of 2.20 meters and from each centre of sub triangle, one core of sample was taken with the help of augur (10 cm diameter). Circular soil cores were collected at three consecutive depths from surface (0-15, 15-30, 30-60 cm) and collected in plastic bags. Two sets of samples were collected by quartering technique from three triangles of three depths. Immediately after sampling, excess water was drained off and visible root fragments were separated and stones removed manually. One set was used for estimating dehydrogenase enzyme and the other was air dried, sieved with 2 mm sieve and stored in polythene bags for analysis of soil physico-chemical properties.

Soil dehydrogenase activity was estimated by reducing with 2,3,5 triphenyltetrazolium chloride (TTC) as per Klein *et al.*, 1971. Results were expressed in µg TPF g^{-1} day^{-1}. Soil pH was measured with glass electrode (1:2.5 soil: water ratio) by using pH meter (Model 362, Systronics, India) and electrical conductivity was measured by using EC meter (Model 361, Systronics, India). Soil moisture was measured gravimetrically, while soil organic carbon was analyzed by means of wet digestion as per Walkley and Black (1934). Potassium and calcium were estimated by flame photometer (Model 128, Systronics, India). Phosphorus was determined by Olsen's (1854) method by using spectrophotometer (Model SL-177, Elico, Hyderabad, India).

RESULTS AND DISCUSSION

Significant variations in soil physico chemical properties were observed at different depths and distances from palm (Table 1). The pH ranged from 6.72 to 7.53. Minimum pH was observed at 0-15 cm depth at a distance of 4 m from the palm base and maximum was observed at 30-60 cm depth (at 1 m distance from palm). In general, the soil pH increased with increase in depth. Electrical conductivity of the soils ranged from 0.08 to 0.17 dS/m. Minimum electrical conductivity was observed at a depth of 30-60 cm and at a distance of 3 m and 5 m from palm and maximum EC was observed at 0-15 cm depth (4 m distance from palm). A decreasing trend in EC was observed with increasing soil depth. The organic carbon content at various soil depths ranged from 0.14 to 0.44 % (Table 1). Organic carbon content was minimum at 30-60 cm depth and at a distance of 5 m from the palm base; however, maximum organic carbon content accumulated nearer to the palm (1m distance and a depth of 0-15 cm). A significant decrease in soil organic carbon content was observed with increase in depth and increase in distance from the palm.

Significant variation in available phosphorus was observed at various depths and various distances from the palm in the oil palm plantations (Table 2). The available phosphorus contents ranged from 7.1 to 90.5 kg/ha. Maximum value was recorded at 15-30 cm soil depth at a distance of 5 m from the palm and minimum value was recorded at a depth of 30-60 cm and 3 m distance from the palm base. The available phosphorus decreased as the soil depth increased. Minimum exchangeable potassium was observed at 0-15 cm depth at a distance of 3 m from palm base and maximum content was also observed at 0-15 cm depth, but at a distance of 4 m from palm base. Exchangeable calcium in the oil palm growing soils ranged from 3.0 to 5.7 meq/100g. The minimum calcium content was observed at a soil depth of 0-15 cm and at a distance of 3 m from palm base and maximum content was observed at 30-60 cm soil depth at 5 m distance. In general, with increase in soil depth, the exchangeable potassium decreased, while the exchangeable calcium increased, clearly show casing the antagonism between the two elements.

The dehydrogenase activity at various soil depths ranged from 12.50 to 20.37 µg TPF g^{-1} day^{-1} (Table 3). Minimum dehydrogenase activity was observed at 30-60 cm depth at a distance of 1 m from palm base and maximum was observed at 0-15 cm depth (at 4 m distance from palm base). The dehydrogenase activity decreased as the soil depth increased. Literature also states that the depth of the soil profile is one of the most known and popular environmental factors reducing soil dehydrogenase levels. The distribution of microbes is more under oxic (surface layers) conditions, compared to that of anoxic (deeper layers) conditions (Fierer *et al*., 2003; Wolinska and Stepniewska, 2011). Brzezinska (2006) also reported higher enzyme activity in surface than at sub surface.

Positive correlation was observed between dehydrogenase activity and other physico-chemical properties at a soil depth of 0-15 cm. However, at a depth of 15-30 cm, dehydrogenase activity had a positive relationship only with organic carbon and phosphorus contents. Positive correlation existed only between dehydrogenase activity and potassium at a depth of 30-60 cm depth. It is evident that soil enzymatic activity is strongly correlated with soil organic matter content. The higher organic matter can provide enough substrate to support higher microbial biomass, hence higher enzyme production (Yuan and Yue, 2012). Several authors reported positive correlation between dehydrogenase and organic matter content (Chodak and Niklinska, 2010; Moeskops *et al*., 2010; Romer *et al*., 2010; Zhao *et al*., 2010).

Table 3: Dehydrogenase activity (µg TPF g^{-1} day^{-1}) at different soil depths and distances in oil palm

Distance from palm base (m)	Soil depth (cm)		
	0-15	15-30	30-60
1	16.00	13.80	12.50
2	18.23	13.77	13.53
3	15.40	15.20	14.10
4	20.37	13.67	12.83
5	16.90	14.70	12.70
Mean±SD	**17.38±1.98**	**14.23±0.68**	**13.13±0.67**

Table 1: pH, electrical conductivity and organic carbon at different soil depths and distances in oil palm

Distance from palm base (m)	pH			EC (dS/m)			OC (%)		
	Soil depth (cm)			Soil depth (cm)			Soil depth (cm)		
	0-15	15-30	30-60	0-15	15-30	30-60	0-15	15-30	30-60
1	7.44	7.48	7.53	0.12	0.10	0.09	0.44	0.33	0.27
2	7.21	7.18	7.38	0.15	0.11	0.11	0.44	0.34	0.26
3	6.91	7.22	7.44	0.10	0.09	0.08	0.40	0.38	0.27
4	6.72	6.93	6.93	0.17	0.10	0.09	0.33	0.38	0.26
5	7.19	7.44	7.05	0.10	0.09	0.08	0.27	0.15	0.14
Mean±SD	**7.09± 0.28**	**7.25± 0.22**	**7.27± 0.26**	**0.13± 0.03**	**0.10± 0.01**	**0.09± 0.01**	**0.38± 0.07**	**0.32± 0.09**	**0.24± 0.06**

Table 2: Phosphorus, Potassium and Calcium at different soil depths and distances in oil palm

Distance from palm base (m)	Available Phosphorus (kg/ha)			Exchangeable Potassium (kg/ha)			Exchangeable Calcium (meq/100g)		
	Soil depth (cm)			Soil depth (cm)			Soil depth (cm)		
	0-15	15-30	30-60	0-15	15-30	30-60	0-15	15-30	30-60
1	49.6	32.7	15.0	206.5	233.1	199.1	3.4	5.6	4.8
2	77.4	42.1	14.2	319.0	386.3	384.6	3.2	5.3	4.8
3	78.7	28.1	7.1	196.0	316.0	321.6	3.0	4.3	5.2
4	43.2	70.8	32.9	530.1	378.8	226.0	3.2	3.9	5.5
5	11.0	90.5	17.3	339.1	283.1	259.8	3.1	3.1	5.7
Mean±SD	**52.0± 27.9**	**52.9± 26.7**	**17.3± 9.5**	**318.1± 134.9**	**319.5± 64.7**	**277.6± 175.8**	**3.2± 0.2**	**4.5± 1.0**	**5.2± 0.4**

To conclude, the dehydrogenase activity decreased with a reduction in organic carbon as the soil depth increased. The above findings indicate that the dehydrogenase activity could be used as a measure of overall microbial activity for evaluating soil health in oil palm growing soils of Andhra Pradesh.

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