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RESEARCH PAPER

Relationship between Soil Oxidisable Carbon and Mineral Nutrients in Oil Palm Plantations of Andhra Pradesh

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ABSTRACT

A study was undertaken to assess the status of labile carbon and its contribution to the total organic matter pool and mineral nutrients in soils and to evaluate their present status of productive potential for better understanding of maintaining soil nutrient status for higher productivity. Results revealed that the soils were very acidic to slightly alkaline in nature. Soil oxidizable carbon in general was very low and the contents varied from 1.6 to 12.9 g kg^{-1} in West Godavari, 1.9 to 10.5 g kg^{-1} in Krishna and 2.30 to 16.00 g kg^{-1} Khammam districts with a mean value of 5.4, 5.5 and 7.0 g kg^{-1} respectively. The values of electrical conductivity of the soils were low, varying from 0.015 to 0.352 dSm^{-1} with an average value of 0.102 dSm^{-1}. The organic carbon content in general was very low and the contents varied from 2.2 to 12.1 g kg^{-1} with a mean value of 5.2g kg^{-1}. The cation exchange capacity of the soils varied from 5.21 to 19.05 cmol (p$^+$) kg^{-1}. The available phosphorus and potassium ranged from 4.2 to 161.9 kg ha^{-1} and 45 to 1008 kg ha $^{-1}$ respectively. The available Sulfur content of the soils varied between 2 and 167 mg kg^{-1} with a mean value of 19.5mg kg^{-1}. Among micronutrients, zinc was found to be most deficient element and the overall, 64.7% of the studied area was in deficient class.

Key words: Oil Palm, labile carbon, soil organic carbon, soil fertility status

INTRODUCTION

Oil palm (*Elaeis guineensis Jacq*) is a major plantation crop and a highly demanding crop for nutrients both for early growth and production. Hence nutrient mining and soil productivity decline are the major concern and so also soil quality. When planted on soils with low inherent fertility, oil palm requires more agronomic inputs to ensure adequate yields. Soil is the largest pool of terrestrial organic carbon in the biosphere, storing more C than is contained in plants and the atmosphere combined (Schlesinger, 1997). The abundance of organic C in the soil affects plant production, and its role as a key control of soil fertility and agricultural production has been recognized for more than a century (Dokuchaev, 1883; Hilgard, 1906; Jenny, 1941; Tiessen *et al.,* 1994).

The patterns and controls of soil organic carbon (SOC) storage are critical for the understanding of biosphere, given the importance of SOC for ecosystem processes and feedback of this pool to atmospheric composition and the rate of climate change (Trumbore *et al*., 1996; Woodwell *et al*., 1998). Our capacity to predict and ameliorate the consequences of climate and land cover change depends, in part, on a clear description of SOC distributions and the controls of SOC inputs and outputs. Many important global and regional SOC budgets are available (Schlesinger, 1977; Post *et al*., 1982; Eswaran *et al*., 1993; Kern, 1994; Batjes, 1996) and for some biomass, like temperate grasslands, major environmental controls of SOC have been described (Parton *et al.,* 1987; Burke *et al.,* 1989). SOC storage is controlled by the balance of C inputs from plant production and outputs through decomposition (Jenny, 1941; Schlesinger, 1977).

Soil organic matter (SOM) has many functions, the relative importance of which differs with soil type, climate, and land use. The quality of soil organic matter in the form of oxidizable C and total C (Blair *et al*., 1995; concomitant with increased interest in modelling C pools Armstrong *et al*., 1999) has been of increased interest in measuring the size of different C pools. These measurements give an indepth knowledge in understanding the factors affecting SOM quality by use of wide range of techniques (Lefroy *et al*., 1995a). The amount and dynamics of soil C differ with soil specific chemical groups, such as humic and fulvic acids type, particularly mineralogy, with climate and humins. SOC turn over occurs relatively rapidly, however, it depends on rate of decomposing organic materials.

Soil organic carbon, which is a major component of soil organic matter is considered perhaps most important indicator of soil quality and productivity. The soil oxidisable carbon (SOC-labile pool) plays an important role in the oil palm production (especially sandy soils of AndhraPradesh), through beneficial influence on microbial turnover of mineral nutrients in soils and also act as sensitive indicator of changes in soil quality. Relationship between soil oxidizable carbon and physical and chemical properties exists and varies with organic carbon, soils and environment (Queiroz Neto and Castro, 1974; Lepsch and Buol, 1986; Ker, 1997; Bol and Eswaran, 2000; Callegari, 2008) and other factors like high acidity, low base saturation, relatively cold altitude climate, stable geomorphic surfaces and complex organomineral formations.

The present investigation has been undertaken to assess the status of labile carbon and its contribution to the total organic matter pool and mineral nutrients in soils and to evaluate their present status of productive potential for better understanding of maintaining soil nutrient status for higher productivity.

MATERIAL AND METHODS

Soils of one hundred twenty nine oil palm plantations from eighteen mandals representing three districts of Andhra Pradesh (13 mandals from West Godavari, 3 from Krishna and 2 from Khammam districts) were collected by compositing. Soil samples collected were air-dried for three days and processed. Processed soils were analyzed for SOC by Chromic acid digestion (Wet digestion) method (Jackson, 1973). The pH (1: 2.5w/v ratio) (Jackson, 1958) electrical conductivity and all the nutrients were determined using standard methods (Black, 1965). Phosphorus was analysed by using Olsen's method (Olsen *et al.,* 1954). The exchangeable K, along with Ca and Mg were usually determined in neutral normal ammonium acetate extract of soil. K is estimated by using a flame photometer (Model 128μc, Systronics, Hyderabad) and Ca and Mg Atomic absorption spectrophotometer (Model GBC 932AA, Advance scientific equipments, Hyderabad). Statistical analysis was done by following the method described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The soil samples collected at different depths (0-15, 15-30 & 30-60) from thirty six villages comprise of thirteen mandals of West Godavari district of Andhra Pradesh representing the intensive oil palm growing areas (Table 1). Soils were acidic to slightly alkaline in nature. The values of electrical conductivity of the soils were low, varying from 0.015 to 0.352 dSm^{-1} with an average value of 0.102 dSm^{-1}. The organic carbon content in general was very low and the contents varied from 2.2 to 12.1 g kg^{-1} with a mean value of 5.2g kg^{-1}. The cation exchange capacity of the soils varied from 5.21 to 19.05 cmol (p^+) kg^{-1}. The available phosphorus and potassium ranged from 4.2 to 161.9 kg ha^{-1} and 45 to 1008 kg ha $^{-1}$ respectively. The available sulfur content of the soils varied between 2 and 167 mg kg^{-1} with a mean value of 19.5mg kg^{-1}. Levels of low status of phosphorus were highest in Devarapalli, Dendulur, Eluru and Chagallu mandals (100%) while of potassium it was in Devarapalli (83%) followed by Jangareddygudem (60%), Mandal.

The overall nutrient index values of phosphorus and potassium were 1.39 and 1.85 respectively. The magnitude of sulphur deficiency was highest in Devarapalli mandal (83 per cent) followed by Nallajerla and the overall nutrient index value was 1.93. Among micronutrients, zinc was found to be the most deficient element and 64.7 per cent of the studied area was deficient and the overall nutrient index value was 1.45. Low organic matter and phosphorus status coupled with low CEC of these soils suggests that there is decline in fertility status and requires specific management measures to maintain soil fertility. Only zinc appears to be deficient in all the mandals and thus, judicious application of Zn fertilizer and organic manures is needed for better productivity.

Soils from West Godavari, Krishna and Khammam districts were collected by compositing and studied for status of SOC and mineral nutrients. The study indicated that soils were very acidic to slightly alkaline in nature (Table 2). Soil oxidisable carbon in general was very low and the contents varied from 1.6 to 12.9 g kg $^{-1}$ in West Godavari, 1.9 to 10.5 g kg $^{-1}$ in Krishna and 2.30 to 16.00 g kg $^{-1}$ in Khammam districts with a mean value of 5.4, 5.5 and 7.0 g kg $^{-1}$ respectively. The proportion of SOC in total organic carbon (LOI) increased with increasing soil organic matter content. The micronutrients especially Fe, Zn, and Cu were highly influenced by SOC (Table 3). In the present Investigation DTPA extractable micro-nutrients varied widely in oil palm gardens. The Soils were well supplied with DTPA extractable Mn and Cu.

Relationship of SOC with availability of phosphorus (P) is not significant in all the soils which suggests that the available P included mostly inorganic P and organic P is low (Table 4). A positive significant relation (r = 0.465*) obtained with available potassium

(K) in soils of Krishna district indicates in the release of K from organic complexes, but a positive and non-significant relationship in West Godavari and Khammam districts suggest that the labile carbon cannot be used as a measurement of available K in these soils. There was a significant positive correlation of SOC with available sulfur (S) (0.498**) in soils of West Godavari district but it was significant and negative (-0.367*) in soils of Krishna district. SOC showed significant and positive relation with iron (Fe) and zinc (Zn) (r = 0.597** and 0.508**) indicating the tendency of organic matter to control Fe and Zn content in soils of Khammam district. Similarly, copper (Cu) in soils of West Godavari district correlated significantly and positively with SOC. Thus, it can be concluded that availability of S, Fe, Zn and Cu is dominantly influenced by SOC.

This paper provides an overview of the major challenges confronting the measurements of SOM from oxidation of soil carbon with methods based on microbial turnover of nutrients in soils. The purpose of this paper is to facilitate the discussions on the fertility status of soils in various oil palm growing areas and to relate to its productive potential which would be of prime importance for developing appropriate management practices for increased production.

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Table 1: General characteristics of the soils of potential oil palm growing areas in West Godavari district of AndhraPradesh.

Mandal	Villages	Plantations	Age (yrs)	Soil type	Drainage	Permeability
T.Narsapuram	3	7	10-12	Red soil with compact clay subsoil	Well drained surface, restricted subsoils	Rapid to low
Buttaya gudem	2	3	11	Red soil with compact clay subsoil's	Well drained surface, restricted sub soils	Rapid to low
Pedavegi	3	11	9-15	Red soils	Moderate	Moderate
Jangareddy gudem	6	8	12-15	Red soils	Well drained	Moderate
Nallajerla	3	9	8-13	Red soils and part black Soils	Low to Moderate	Low to moderate
Devarapalli	3	3	7-10	Upper sandy soils with red clay subsoil's	Excessive drained & Restricted subsoils	Rapid to very low
Chagallu	3	5	9-13	Upper sandy soils withred clay subsoil's	Excessive drained surface soils	Rapid to very low
Nidadavolu	2	4	10-12	Upper sandy soils with red clay subsoil's	Excessive drained surface soils	Rapid to very low
Tadepalligudem	4	5	10-13	Red subsoil's and part black soils	Excessive drained surface & restricted sub soils	Rapid to very low
Bhimadole	2	3	17	Black soils with Fe concretions in sub soils	Poor	Low
Denduluru	1	3	13	Red soils	Moderately drained	Moderate
Eluru	2	3	11-13	Red soils	Moderately drained	Moderate
Kovvur	2	2	10	Red soils	Moderately	Moderate

Table 2: Electrical conductivity (cmol (p +) kg^{-1}), Soil oxidisable carbon (g kg^{-1}), P& K in kg ha^{-1}, S in mg kg^{-1} in soils

District		pH	EC	Soil Oxidi-sable Carbon	Available nutrients		
					P	K	S
W.Godavari	Range	4.17-8.30	0.02-1.00	1.60-12.90	4-162	45-1008	2-167
	Average	6.30	0.11	5.40	47	216	167
Krishna	Range	6.58-9.09	0.03-0.28	1.90-10.50	13-151	48-368	8-103
	Average	8.41	0.16	5.50	46	142	30
Khammam	Range	4.25-8.28	0.02-1.80	2.30-16.00	4-130	40-914	3-96
	Average	5.86	0.18	7.00	28	278	29

Table 3: Total Organic Carbon (TOC) and micronutrient status of soils

Districts		TOC(g kg^{-1})	Available micronutrients (mg kg^{-1})			
			Fe	Mn	Zn	Cu
West Godavari	Range	2.90-16.00	1.20-54.30	1.30-62.90	0.01-2.20	0.08-3.86
	Average	6.80	9.80	13.50	0.56	1.05
Krishna	Range	2.50-13.90	2.26-8.96	3-21	0.06-1.78	0.62-1.88
	Average	7.60	3.93	8	0.53	1.07
Khammam	Range	3.00-21.10	4-95	11-61	0.18-1.12	0.25-1.66
	Average	9.20	18	28	0.65	0.73

Table 4: Coefficient of Correlation 'r' between the Soil oxidisable carbon and mineral nutrients

District	P	K	S	Fe	Mn	Zn	Cu
West Godavari	-0.026	0.108	0.498**	-0.088	-0.017	0.035	0.298
Krishna	-0.046	0.465*	-0.367	0.062	-0.229	-0.195	-0.242
Khammam	0.355	0.192	-0.157	0.597	-0.188	0.508**	-0.05

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