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Sulphur Mineralisation and Oxidation Potential of Some Soil Types of Kerala

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Abstract: Four soil types from Kerala *viz*. sandy (Oxic Quartzipsamments), red sandy loam (Arenic Paleustults), laterite (Oxic Haplustults) and *kari* (Tropic Fluvaquents) were taken for studying their rate of S-mineralization and oxidation potential. In case of *kari*, sandy and laterite soils, the cumulative SO_4^{2-}-S mineralisation increased up to 40 days after incubation, then reached a plateau after 60 days and subsequently, increased after 80 days of incubation. In case of red sandy loam, increase in SO_4^{2-}-S mineralisation was noticed up to 40 days after incubation followed by a slight decline and subsequent, increase after 80 days of incubation. Oxidised sulphur after six days of incubation was found to be highest in *kari* soil followed by sandy, laterite and red sandy loam soils. The oxidative capacity of the soils for sulphur followed the same trend. (***Key words**: Sulphur, mineralisation, oxidation potential, soil types, Kerala*)

Around 80-90 per cent of the sulphur in soil is present in organic fraction. Its availability in soil depends on its rate of mineralisation. In contrast to nitrogen, the mineralisation and immobilisation of sulphur was not studied in any greater detail until the last decade (Classon & Ramaswami 1990). Classon and Ramaswami (1990) reported that the rate of mineralisation of native sulphur in soils was higher during the first or second week, when environmental factors such as moisture and temperature are favourable.

Elemental sulphur is an important source of sulphur fertilizers. It has not been widely accepted because it is not available until oxidised to SO_4^{2-} ions, thus there is lag period before it is available crop (Germida & Janzen 1993). The information on the rate at which soils oxidise elemental sulphur under favourable conditions (oxidative capacity) is necessary to determine the level of variability in oxidative capacity among soils and to make compensatory adjustment in application rate (Janzen & Bettany 1987). Earlier investigations have indicated considerable variability in the activity among soils (Attoe & Olsen 1966; Vitolins & Swaby 1969; Rehm & Caldwell 1969).

Very few studies have been carried on sulphur in the coconut growing soils of India. These works are mainly based on the sulphur status and is not in any way reflective of the sulphur supplying capacity of the soils. The present investigation aims at studying the sulphur mineralisation and oxidation potential of four different soil types of Kerala.

Materials and Methods

Four different soils types *viz* sandy (Oxic Quartzipsamments), red sandy loam (Arenic Paleustults), laterite (Oxic Haplustults) and *kari* (Tropic fluvaquents) were taken for studying their rate of S-mineralization and oxidation potential. Soil samples from surface soils (0-30 cm) were collected, air-dried and passed through 2 mm sieves. The soils were analysed for its mechanical composition, pH (1:2.5), organic carbon, (using procedure outlined by Jackson 1967) and SO_4^{2-}-S colorimetrically by the method prescribed by Palaskar *et al.* (1981). Soil characteristics are given in table 1.

Table 1. Basic characteristics of soils

Soil type	pH	Org.C ($g\ kg^{-1}$)	SO_4^{2-}-S ($mg\ kg^{-1}$)	Mechanical composition (%)		
				Sand	Silt	Clay
Sandy soil	5.9	2.5	Trace	98.0	0.20	0.7
Red sandy loam soil	5.3	4.8	1.45	76.0	1.92	22.0
Laterite soil	5.45	4.1	0.36	45.0	9.95	35.0
Kari soil	4.2	52.0	1.45	7.2	26.5	52.4

In the incubation experiment for mineralisation studies, 30 g sample of field moist soils were transferred into sintered glass leaching tube. The soil was retained in sintered glass leaching tube by means of glass wool pad below it. A thin glass wool pad was placed over the soil to avoid dispersing the soil when solution was poured. The soil was leached with 150 mL of 0.01 *M* KCl in 4-5 increments to remove mineralised S in soil and excess water allowed to drain for 24 hours under gravity. The leaching was done every 20 days up to a period of 80 days. The moisture contents of the columns were adjusted by weighing the columns every 3 days and adding deionized water for adjustment. The leachates thus obtained were analysed for SO_4^{2-} colorimetrically by the method prescribed by Palaskar *et al.* (1981). The experiment was conducted in three replications.

For oxidation potential studies, 250 g of soil was taken in a bottle. Elemental S @ 1000 ppm was applied to each bottle. The elemental S had mean particle diameter of 0.119 mm. These bottles were covered and kept at room temperature for six days. The incubation period was relatively short (6 days) to minimize the effects of organic sulphur mineralisation. Water was added to maintain the moisture content at field capacity level. After six days, samples were drawn and analysed colorimetrically by Palaskar *et al.*(1981) method. The experiment was conducted in three replications. The procedure used for calculation of oxidation potential was from Janzen and Bettany (1987). The equation is as under:

$$k = \left[1-\left(1-\frac{m}{m_0}\right)^{1/3}\right] g \frac{D_0}{2t}$$

D_0 = Diameter of elemental sulphur particle (0.119 mm)

m = mass of oxidized sulphur (g)

m_0 = initial mass of elemental sulphur (g)

g = density of sulphur (2.07 $Mg\ m^{-3}$)

t = time (days)

Results and Discussion

The sulphate-S production as influenced by the time of incubation is depicted in Fig. 1. The rate of mineralisation of sulphur, in case of *kari*, sandy and laterite soils increased from 20 days after incubation to 40 days after incubation. Further, a plateau was reached after 60 days of incubation *i.e* decline in net mineralisation of sulphur followed by increase up to 80 days after incubation. This increase in rate of mineralisation up to 40 days after incubation might be due to the presence of organic matter which can be easily decomposed into plant available fraction (SO_4^{2-}-S). Further being mainly coconut growing soils, the crop residue addition is mainly of coconut. Lignin is an important constituent of coconut ranging to as high as 31.9 per cent in leaves (Thomas *et al.* 1997). Thus decline up to 60 days after incubation may be due to highly resistant organic complex *e.g.* lignoprotein complexes present which required more time for decomposition (Waksman & Tenney 1927). Only when these materials have broken down into simpler compounds then again the rate of mineralization of sulphur increased as evident at 80 days after incubation. However, the trend in case of red sandy loam was different. The rate of sulphur mineralization decreased from 20 days after incubation to 60 days after incubation, after which it registered an increase up to 80 days after incubation.

The rate of mineralisation of sulphur was more in case of *kari* soil (0.913 mg SO_4^{2-}-S/ day)

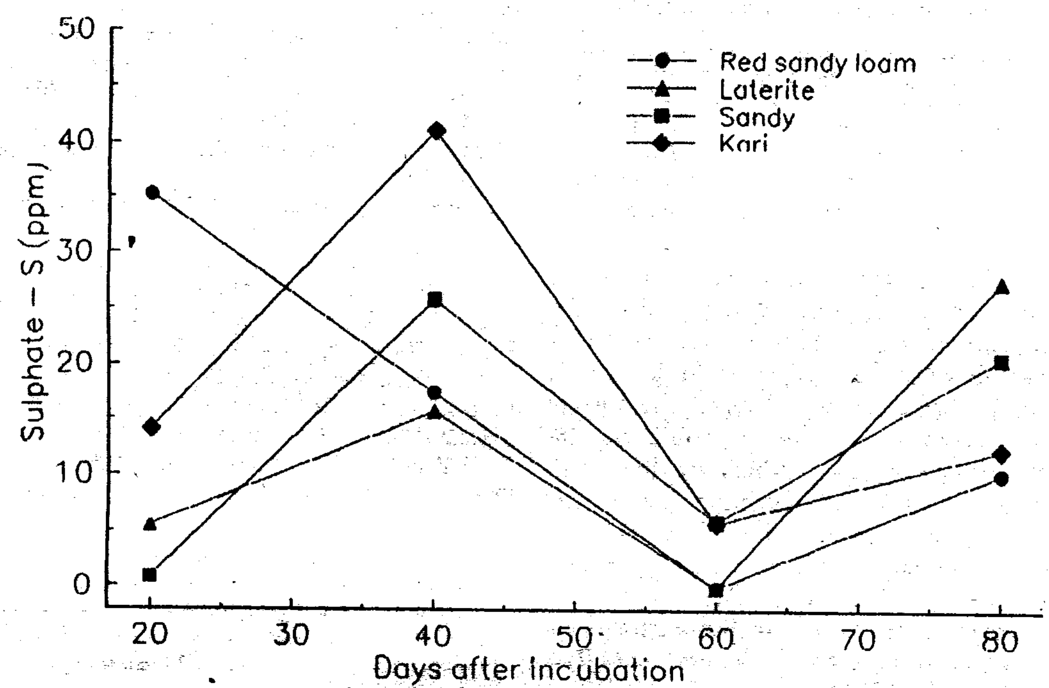

Fig. 1. Sulphate S mineralised

followed by sandy (0.812 mg SO_4^{2-}-S/ day), laterite (0.647 mg SO_4^{2-}-S/ day) and lastly red sandy loam (0.414 mg SO_4^{2-}-S/ day) soils (Table 2). The rate of mineralisation is more in *kari* soils as the organic carbon content is more. This can be corroborated by the findings of Rajendra Prasad *et al.* (1984). However, in case of sandy soils even though the organic carbon was least of all the four soil types under study, the rate of mineralisation was more than red sandy loam and laterite soils. This may be due to the presence of easily decomposable organic matter. Secondly, no significant correlation was observed between organic carbon and rate of mineralisation. This has also been reported by Williams (1967). Mineralisation potential of sulphur in sandy and laterite soils has been found to be negative. This may be due to the presence of small amounts of readily available SO_4^{2-}-S as stated in table 1, leading to immobilisation of the mineralised native sulphur by the microbes. This can be further substantiated by fig.1 which clearly depicts the SO_4^{2-}-S production trend after 20 days of incubation.

Table 2. Parameters and correlation coefficients of linear relationship between cumulative sulphur mineralised in soils and incubation time

Soil type	Intercept	x coefficient ($\mu g\ SO_4^{2-}\ S\ day^{-1}$)	R^2 value
Sandy soil	-12.38	0.812	0.95**
Red sandy loam soil	30.10	0.414	0.87**
Laterite soil	-8.20	0.647	0.87*
Kari soil	5.10	0.914	0.85**

** Significant at 1% level

Oxidised sulphur after six days of incubation was found to be highest in *kari* soil followed by sandy, laterite and red sandy loam soils (Table 3). In fact this also follows the trend as mentioned for rate of mineralisation. Highest oxidizable sulphur present in the *kari* soil can be attributed to heavier soil texture, which oxidises more rapidly than the lighter ones (Burns 1984; Classon & Ramaswami 1990). Secondly, the organic matter content was very high in *kari* soils thereby leading to more

Table 3. Oxidation potential of sulphur in soils

Soil type	Oxidised S after 6 days (mg kg^{-1})	Oxidative capacity (μg SO_4^{2-} S cm^{-2} day^{-1})
Sandy soil	22.48	15.50
Red sandy loam soil	17.17	11.82
Laterite soil	20.51	14.13
Kari soil	24.18	16.68

sulphur oxidation. This implies that heterotrophic oxidizers are stimulated whereas the chemoautotrophs are inhibited by the presence of high carbon substrate (Pepper & Miller 1978). However in case of other soil types, the organic matter content being low, it could be the chemoautotrophic oxidizers which get stimulated. But, in case of coarse soils like sandy soil, higher porosity might have influenced the oxidation rates. The wide differences in oxidative capacity cannot be related to any single factor; rather it is governed by the integrated effects of a number of parameters and no single parameter is predominant in effect (Janzen & Bettany 1987).

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